National Center for Research in Policy and Practice

Findings from a Survey of State Science Leaders: Year 2

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Executive Summary

This report presents results from a study of the Council of State Science Supervisors (CSSS). CSSS is a professional association for state science leaders that works to sustain and nurture a dynamic learning community and to empower its members to be effective and articulate advocates for quality science education at the local, state, and national levels. Given that many state science supervisors are working to support implementation of the *Framework for K-12 Science Education,*[1] we sought to develop an understanding of CSSS members' roles and responsibilities, as well as their use of research to inform state implementation decisions. While state education agencies play key roles in supporting the implementation of standards that align with the *Framework*, with state science supervisors taking a lead role, little is known about how these individuals use research to inform their decisions.

The research questions guiding the study were:

- What roles and activities do CSSS members take on and participate in within the association and their states?
- What research findings and research-based resources do CSSS members use to inform their efforts to promote implementation of the *Framework*? What research findings and research-based resources do they share with local education leaders?
- To whom do CSSS members turn for research to inform their state's decisions regarding implementation of the *Framework*?
- How, if at all, are CSSS member roles and activities associated with their research networks?

Research Design and Methods

We administered a survey focused on the roles that CSSS members take on in the organization, the state-level activities in which they participate, how they use research, and to whom they turn for research to inform decisions related to statewide implementation of the vision for science teaching and learning described in the *Framework*. While survey items pertaining to CSSS members' roles and activities were developed in collaboration with CSSS members,[2] items related to research use were previously developed and validated via a national survey conducted by the National Center for Research in Policy and Practice (NCRPP).[3] Items related to CSSS members' research networks (i.e., to whom they turn for research) drew on prior social network studies[4] and researcher expertise.

The survey was administered twice at the annual CSSS conference, once in April 2016 and once in April 2017. The data were collected just after CSSS concluded a sustained professional development project for state science supervisors (Building Capacity in State Science Education or BCSSE) and before it began a research-practice partnership to improve equity by building coherence in science education within and between states (Advancing Coherent and Equitable Systems of Science Education or ACESSE).

This report primarily focuses on results from the second survey administration in April 2017,[5] with significant changes between years reported as applicable. In spring 2017, a total of 58 individuals responded to the survey from 36 states; these individuals included state members (n=40), associate and honorary members (n=11), and affiliate members (n=7) of CSSS.

The overall response rate for the survey in 2017 was 41%, compared to 62% in 2016. The lower response rate in 2017 can be attributed to: 1) the inclusion of a more diverse population representing different kinds of CSSS members (defined below); and 2) membership turnover, as the majority of individuals (i.e., 14 of 20) who responded in 2016 but not in 2017 left their state-level positions or no longer belonged to CSSS. On average, respondents in 2017 had four years of experience as state science leaders, and the majority of the sample was white and female.

Definition of Research and CSSS Membership Used in the Study

For the purposes of this study, we defined "research" as an activity in which people employ systematic, empirical methods to answer a specific question. In this sense, research is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

We delineated four types of CSSS members: (1) *State members*, who are employees of their state Department of Education and are designated by their chief state school officer as having responsibility for science education statewide; (2) *Associate members*, who are former state members; (3) *Affiliate members*, who are interested in the vision, mission, purposes, and goals of CSSS and are often engaged in research related to science education; and (4) *Honorary life members*, who are nominated by the CSSS Board and elected by a majority of members for their significant service to CSSS and/or to science education. Given their prior history as state leaders, we combined associate and honorary members in our analyses.

Findings Related to Roles and Activities

CSSS roles. The survey asked respondents about the roles they have assumed within CSSS. In response to these items, CSSS members most often reported serving as conference presenters or participants, at both their state science conferences and the CSSS annual meeting. As compared to other activities, they reported less frequent engagement in CSSS leadership activities, such as committee and board meetings. Overall, associate, honorary, and affiliate members were more often engaged in out-of-state or national activities than state members.

CSSS activities. Respondents were asked to report how often they participated in a range of CSSS activities over the last three years. Overall, respondents reported frequently accessing information from the CSSS listserv, as well as participating in CSSS-sponsored webinars, consulting with CSSS members, and collaborating with other states. State members were significantly less likely to report visiting other states and presenting at national meetings than associate, honorary, and affiliate members. This difference may be related to variation in the roles and responsibilities of state and non-state members.

State activities. Respondents also reported engagement in a variety of state-level activities in the areas of curriculum, instruction, assessment, and professional development. They reported being highly involved in state policy decisions related to science standards, yet they were less involved with the implementation of curricula that reflected those standards. They also reported playing key roles in assessment and professional development, although few respondents had authority to make decisions related to resource allocation or contract selection for assessment systems or professional development providers.

Professional development. Based on a request from CSSS leaders, the 2017 survey included items related to teacher professional development (PD). Respondents were asked to identify the PD offered in their state that afforded teachers the best opportunity to learn about the *Framework*. Findings revealed that these opportunities tended to be led by a state agency or local leader and funded by federal grant programs. These PD opportunities covered foundational concepts such as the three dimensions of science learning in the *Framework, Next Generation Science Standards* (NGSS), or instructional planning; however, they tended to pay less attention to designing three-dimensional assessments and developing students' skills.

Findings Related to CSSS Member Research Use

Specific pieces of research found useful or shared with others. The survey asked respondents to name a specific piece of research they found useful for informing their state's decisions related to implementation of the *Framework*, as well as a piece of research they shared with district or school leaders. The research respondents used to support implementation of the *Framework* most often focused on student learning and classroom assessment, while the research they shared with local leaders most often focused on classroom assessment and pedagogical practices. Few respondents named research focused on the needs or assets of particular student subgroups (e.g., by race/ethnicity, gender, socioeconomic status, or language). Overall, the pieces of research named were primarily research reports or policy briefs, particularly those published by the National Academies of Science, Engineering, and Medicine, as well as peer-reviewed journal articles.

Research trustworthiness. Respondents were asked to indicate why they found the particular pieces of research they named trustworthy. The most often cited reasons were if the research findings applied to their state context, or if the research gave them new ideas to support implementation of the *Framework*. A less commonly cited reason was that the research methods were rigorous.

Sources used to obtain research. The survey asked respondents how often they obtained research from a list of 13 sources. Of these, many respondents indicated obtaining research through CSSS or colleagues in their state departments of education. Far fewer respondents indicated seeking out research from the National Science Education Leadership Association (NSELA) or from the What Works Clearinghouse (WWC).

Efforts to acquire research. We asked respondents to indicate whether they would seek out research under different conditions. Although a majority said they would look for research to inform a new problem or decision, fewer said they would contact researchers directly under these circumstances, especially researchers they did not already know.

Findings Related to Research Networks

Research networks. The survey asked CSSS members to whom they have turned for research to inform their state's implementation of the *Framework*. Findings from these social network questions revealed that associate, honorary, and affiliate members served as prominent sources of research in the areas of curriculum, instruction, assessment, and professional development. University faculty not affiliated with CSSS were also frequently named as sources of research. Additionally, new state members were more likely than veteran state members to name individuals from their own states as sources of research. And, while some respondents facilitated the exchange of research within the professional association, or between CSSS members in different states, others facilitated the exchange of research between CSSS members and researchers unaffiliated with the association.

Relations between activities and networks. Our Year 1 report indicated that an important next step in this study was to explore relationships between CSSS members' roles and activities and their use of research. We used Year 2 data to examine these relationships, and found that participation in structured CSSS activities, particularly substantive meetings as compared to planning meetings or more informal interactions such as webinars, were important for facilitating the exchange of research among CSSS members.

Introduction

The core studies conducted by the National Center for Research in Policy and Practice (NCRPP) focus on research use among school and district leaders, but leaders in state education agencies also make use of research to inform their decision making. Contrary to many depictions of state agencies, state education agency leaders have many social ties across departments and with external organizations, ties along which research flows.[6] Nonetheless, research use among state education agency leaders remains a largely understudied phenomenon. Given that professional associations can be an important source of social support and research-based resources that help state education agency leaders do their jobs effectively,[7] our study focuses on the lead professional association for state leaders in science education, the Council of State Science Supervisors (CSSS).

CSSS is a professional organization composed of science education specialists who serve at the state, territorial, or the protectorate educational agency in the United States and U.S. Territories. Its members primarily include current supervisors of science education in state education agencies. Within their states or jurisdictions, these supervisors play key roles in directing efforts at improving school science instruction and in ensuring excellence and equity in science education. As a professional organization, CSSS organizes meetings, facilitates consultations between state leaders, provides learning opportunities to its members, and serves as a linkage point from outside organizations to schools and districts. Beyond current state supervisors, CSSS members include former supervisors (i.e., associate members) as well as a small number of honorary members and research affiliates. Overall, CSSS members are knowledgeable about state standards, curriculum, assessment systems, and professional development providers, as well as state-level initiatives to improve science education.

One such initiative is the recent implementation of the vision of equitable science teaching and learning described in *Framework for K-12 Science Education*,[8] which calls for significant changes to science education to ensure that all students become proficient in science. It calls for systems to be organized around building understanding of disciplinary core ideas over time, engagement of students in the practices of science and engineering, and application of crosscutting concepts that unify science. It also calls for science teaching to promote equity and—as one strategy for doing so—to connect learning opportunities to students' everyday experiences, interests, and identities. It is based on a large body of research on how students best learn science[9] and on careful observations of the real work of scientists and engineers.[10] In recent years, a number of states have chosen to adopt the *Next Generation Science Standards*[11] or standards based on the *Framework*, an important first step to reorganizing science education to achieve the ambitious aims laid out in the *Framework*. Additional changes to curriculum, instruction, teacher preparation and professional development, and student assessment will be required, especially to transform science education opportunities for an increasingly diverse student population.[12]

Given that many state leaders in science education are working to support implementation of the *Framework*, we sought to develop an understanding of CSSS members' work, as well as their use of research to inform their state's implementation decisions. We asked:

- What roles and activities do CSSS members take on and participate in within the association and their states?
- What research findings and research-based resources do CSSS members use to inform their efforts to promote implementation of the *Framework*? What research findings and research-based resources do they share with local science education leaders?
- To whom do CSSS members turn for research to inform their state's decisions regarding implementation of the *Framework*?
- How, if at all, are CSSS member roles and activities associated with their research networks?

In this report, we provide information related to the study design and sample, and findings on roles and activities in which respondents reported engaging as CSSS members and state leaders. We also present findings related to CSSS members' research use, with respect to the sources they sought for research to inform their state's decisions, as well as their efforts to acquire research. In addition, we investigate CSSS members' social networks, and specifically how research-related information flows between members. We also examine relationships between characteristics of CSSS members' networks and their activities in the association. Finally, we present key conclusions drawn from the survey data analysis.

Study Design

In spring 2017, we surveyed a national sample of CSSS members to explore the questions outlined above. A similar version of this survey was administered to CSSS members in spring 2016, with some adaptations made in 2017 based on consultation with CSSS leaders. Additionally, there were some key differences in the population surveyed and resulting sample between 2016 and 2017 (which we refer to as Year 1 and Year 2, respectively), as well as the data collection procedures. We describe these below, as well as the survey instrument and sample.

Population

Our population included four types of CSSS members, who we placed into three groups. First, *state members* are designated by their chief state school officers as having responsibility for science education statewide. Second, *associate and honorary members* are former state members and are recognized by the CSSS board for their service to the organization. Third, *affiliate members* are individuals interested in the vision and mission of CSSS and are often engaged in science education research. To identify the population for this study, we used a membership list provided by CSSS leaders that included 78 state members, 42 associate and honorary members, and 25 affiliate members.

Overall, the 145 CSSS members invited to participate in spring 2017 represented 47 states. In terms of membership, this group represented a more diverse population than in spring 2016, when the population (n=98) primarily included state members and a small number of associate and honorary members. This difference in population was intentional, as we targeted state members in Year 1, and expanded our focus in Year 2.

Data Collection Procedures

We collected surveys from CSSS members in two ways. First, we distributed the survey at the 2017 Council of State Science Supervisors Annual Conference. All conference attendees who were willing to participate filled out a paper survey, due to the lack of Internet access at the conference center. Second, we sent email messages to any individuals on the membership list who had not yet completed the survey and invited them to complete an online version via Qualtrics. A maximum of three follow-up invitations were sent to these individuals over a one-month period. This process was very similar in Year 1, except that in Year 1 conference attendees were able to complete the survey online rather than on paper.

Survey Instrument

The survey instrument was developed to address our four research questions. Items related to CSSS members' roles and activities were developed in collaboration with CSSS members. Another important set of items was drawn from the previously developed and validated items included in the national survey conducted by the National Center for Research in Policy and Practice (NCRPP).[13] The social network items were developed based on previous studies as well

as researcher expertise. The survey instrument is shown in Appendix A. The definition of all survey constructs, sample items, item response choices, and the total number of items for each construct are provided below.

CSSS roles. This item referred to the roles participants have taken on as CSSS members. We developed a list of nine roles in consultation with CSSS board members, such as: president, secretary, board member, and ad-hoc committee chair. Respondents could choose more than one role and indicate "other" as necessary.

CSSS activities. These items asked participants to report the frequency with which they participated in association activities in the past three years. A list of activities was generated from a review of documents provided by the CSSS Board, then reviewed by Board members. Examples of activities include: annual CSSS meeting participation, consultations with other CSSS members, participation in CSSS-sponsored webinars, and attendance at workshops/talks by researchers. For each activity, respondents were asked how often they participated in the activity, with response choices as follows: Never (1), Once (2), 2-3 times (3), 4 or more times (4).

State leader activities. These items pertain to the activities participants engaged in as part of their work as state science supervisors. In consultation with CSSS board members, we developed a list of such activities across five areas: standards and curriculum (e.g., reviewing state science standards), assessments (e.g., designing state assessments), professional development (e.g., writing contracts for professional development providers), partnerships (e.g., identifying resources to share with districts), and awards (e.g., coordinating student scholarships). Participants were asked to indicate how often they engaged in each activity in the last 12 months. Item response choices for each activity were: Never (1), Rarely (2), Sometimes (3), Often (4), All the time (5).

Teacher professional development. At the request of CSSS leaders, we included five survey items in Year 2 pertaining to teacher professional development (PD). We prompted respondents to think about the PD offered in their state in the last year that they thought offered the best opportunity for teachers to learn about the *Framework for K-12 Science Education*. We asked: (1) who led the PD; (2) how much time teachers spent together in the PD; (3) the period of time over which the PD occurred; and (4) whether particular topics were a minor or major focus of the PD. We also asked about the funding sources (e.g., Title II programs, School Improvement Grants) used to support teacher PD specific to science education.

Research CSSS members found useful. Following an approach used in the national NCRPP survey, we sought to identify individual pieces of research that CSSS members found useful in informing decisions in their state related to implementation of the *Framework*. For each study named, we asked them to identify (if they could) the title, author, year published, publisher, topic, and why they found it useful. We augmented this series of items in Year 2 by asking respondents to indicate why they found that piece of research trustworthy, with response options including statements such as: "I was involved in the research," "The research methods

used are rigorous," "I could relate the findings to my state context," and "It gave me new ideas for how to support implementation of the *Framework*."

Research CSSS members shared with others. We sought to identify individual pieces of research that CSSS members shared with district or school leaders related to implementation of the *Framework*. For each study named, we asked them to identify (if they could) the title, author, year published, publisher topic, and with whom they shared it.

Research acquisition effort. This construct refers to the extent to which an individual exerts effort to acquire research and develop relationships with researchers to address problems or decisions.[14] The scale comprises five items developed by NCRPP, and asked CSSS members to indicate how often they engaged in certain activities, such as looking for research studies or contacting researchers to find out more about articles they have written. Item response choices were: Never (1), Rarely (2), Sometimes (3), Often (4), All the time (5). Analysis suggested moderate internal consistency for the Year 2 sample (n=58, $\alpha = 0.72$), which was similar to the NCRPP national survey (n=73, $\alpha = 0.79$).[15]

Sources where CSSS members obtain research. These items pertain to the sources where CSSS members obtain research, and the frequency with which they consult those sources. Sources included traditional ones, such as university researchers, as well as networks (e.g., professional associations such as the National Science Teachers Association) and media. For each source, we asked how often individuals sought out or acquired research in the past 12 months. Response choices were: Never (1), Rarely (2), Sometimes (3), Often (4), All the time (5).

Research networks. These items sought to identify to whom CSSS members turned in the past 12 months for research to inform their state's efforts to implement the *Framework*. First, participants named up to 12 researchers, state science supervisors, and other colleagues, either within or outside their states. Participants were then asked to indicate how often they turned to each person in the last year, considering all forms of communication such as face-to-face, e-mail, or telephone, with the following response options: 1-2 times per year (1), 3-4 times per year (2), Every 2 months or so (3), Monthly (4), 2-3 times per month (5), and weekly (6). Then, participants were asked what research topics they discussed with each person: curriculum, assessment, professional development, and instruction.

Sample

Of the 145 individuals invited to complete the survey in spring 2017, 58 completed the majority or all of the survey, for an overall response rate of 41%. Of the 48 states in the study population, 36 states, or 75%, were represented in the sample. Whereas 49 respondents completed the paper survey at the CSSS Annual Meeting, 12 respondents completed the survey via Qualtrics. The sample comprised 40 state members, 11 associate or honorary members, and 7 affiliate members, who represented 51%, 26%, and 28%, respectively, of the total individuals surveyed in their membership group.

Table 1 includes characteristics of the survey sample in 2017, with comparisons to the year prior. Although the response rate was lower in Year 2 than in Year 1, the sample was intentionally more diverse in terms of membership type in Year 2. Nonetheless, the sample remained predominantly female and white, and the average respondent had 4-5 years of experience as a state science supervisor. As shown in the table, 33 respondents completed the survey in both years.

Table 1. Survey Respondent Characteristics, Year 1 and Year 2

	Year 1 (2016)	Year 2 (2017)	Both Years
Number of respondents	61	58	33
Response rate	62%	41%	--
States represented	38	36	24
Associate or honorary members	5	11	5
Affiliate members	0	7	0
Self-identified gender	69% female	62% female	65% female
Race/ethnicity	81% white	88% white	81% white
Average experience as state science supervisor, if applicable	5 years	4 years	6 years

CSSS Roles and Activities

Key Findings

- Respondents were more likely to report engagement in conferences than in leadership activities associated with CSSS.
- All respondents reported frequently accessing information from the CSSS listserv, as well as participating in CSSS-sponsored webinars, consulting with CSSS members, and collaborating with other states. However, state members were significantly less likely than associate, honorary, and affiliate members to report visiting other states and presenting at national meetings.
- Respondents reported being highly involved in state policy decisions related to science standards, yet were less involved with the implementation of curricula that reflected those standards. Similarly, respondents reported playing key roles in assessment and professional development, but few had authority to make decisions related to resource allocation or contract selection for assessment systems or professional development providers.
- The professional development that respondents identified as providing the best opportunity for teachers to learn about the *Framework* tended to be funded by federal grant programs, and to be led by a state agency or local leader. These PD opportunities covered foundational concepts such as instructional planning and the three dimensions of science learning in the *Framework* or *Next Generation Science Standards* (NGSS), yet paid less attention to designing three-dimensional assessments and developing students' skills in science.

In this section we report findings from the items related to CSSS members' roles and activities, exploring the frequency of their self-reported involvement. Findings are organized in four groups: CSSS-related roles, CSSS-related activities, state-level activities (standards and curriculum, assessment, professional development, partnership, and awards), and the teacher professional development that respondents found most useful.

Roles Related to CSSS Membership

The CSSS conference was the most frequent activity in which respondents reported engaging, be it as participants or presenters. And, CSSS members were more likely to report engagement in conferences than in leadership activities associated with the professional association. For example, a full 80% of respondents in spring 2017 indicated participating in their state science conference, and 37% indicated presenting at a CSSS conference (see Figure 1). In contrast, just 14% of respondents indicated having served as a CSSS board member. The proportion of

respondents who indicated taking on leadership roles within CSSS, including president, secretary, and board member, remained about the same between 2016 and 2017. However, a larger proportion of Year 2 respondents indicated presenting at the CSSS conference (37% in Year 2 compared to 18% in Year 1), participating in their state science conference (80% in Year 2 compared to 67% Year 1), as well as organizing their state science fair (14% in Year 2 compared to 7% in Year 1).

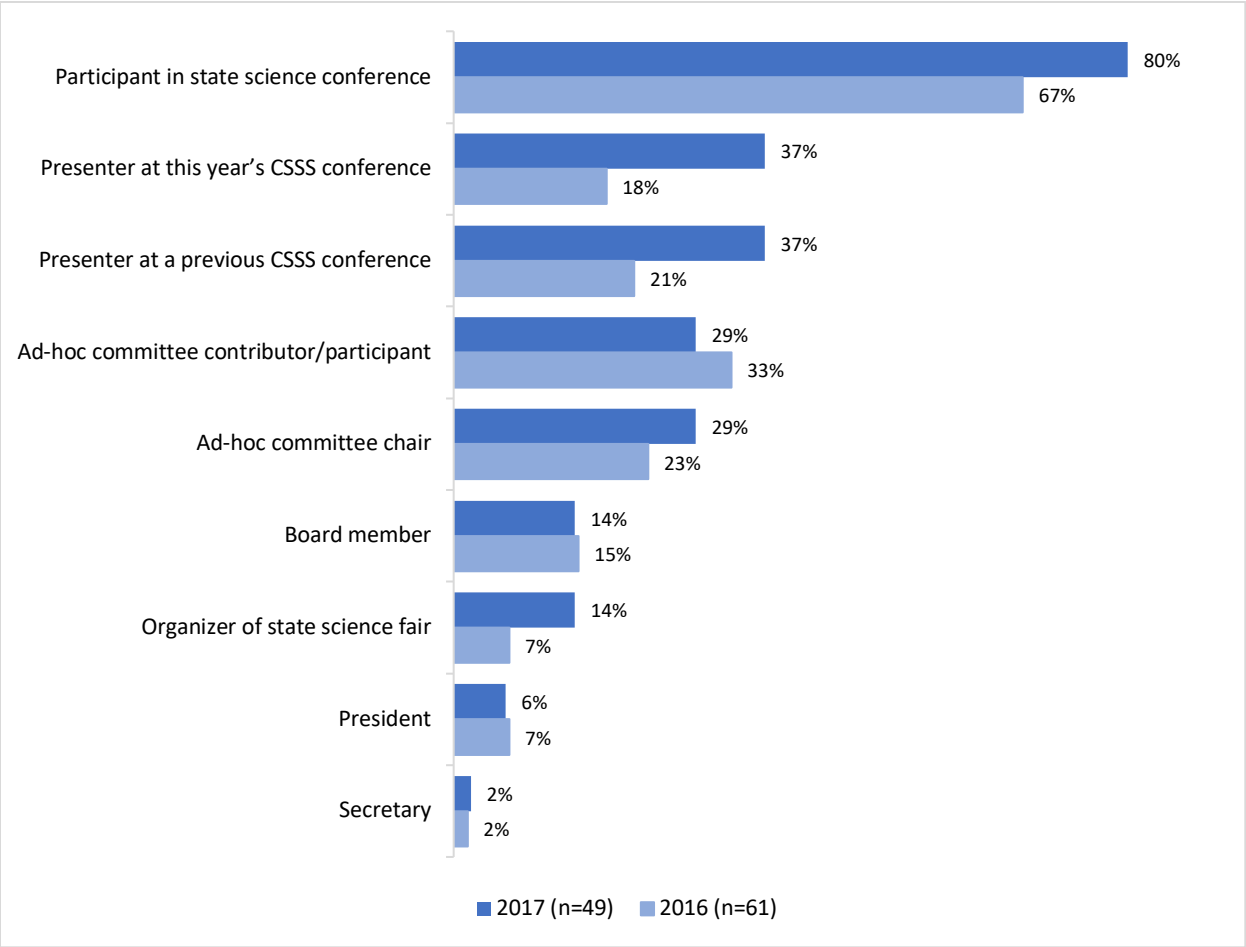

Figure 1. CSSS-Related Roles Assumed by Survey Respondents, Year 1 and Year 2

Activities Related to CSSS Membership

With respect to the CSSS activities that respondents participated in over the last three years, reading information from the CSSS listserv was cited most frequently, with 85% of respondents reporting doing so four or more times (see Figure 2). This finding was consistent between Year 1 and Year 2. Consulting with CSSS members, collaborating with other states, attending workshops or talks by researchers, and participating in CSSS Annual Meetings were also frequently reported activities in both years.

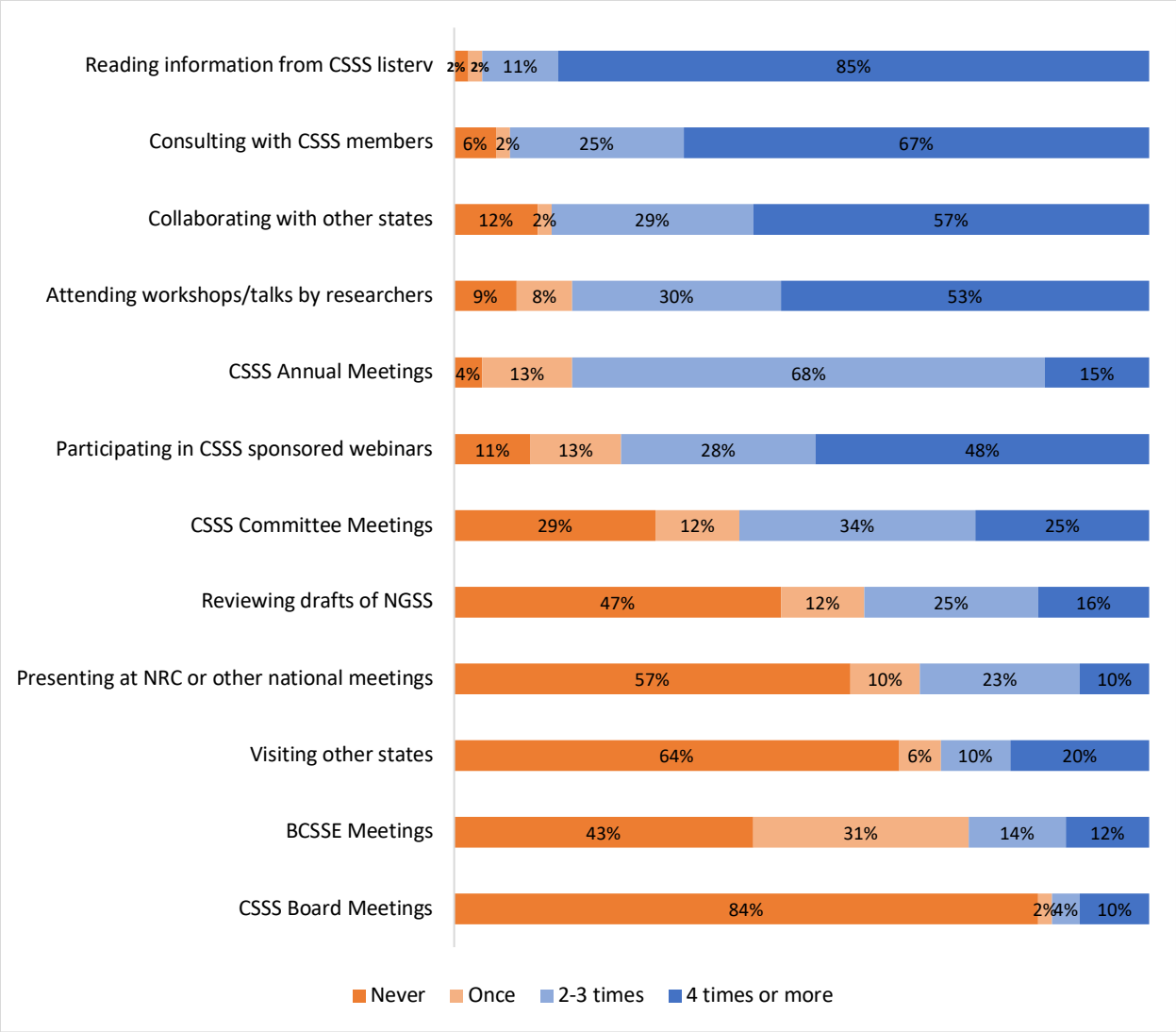

Figure 2. CSSS Activity Participation in the Last Three Years (n=54).

Activities by member type. In general, associate, honorary, and affiliate members engaged significantly more often in out-of-state or national activities than state members ($p<.05$).[16] Specifically, whereas only 19% of state members (n=38) reported visiting other states at least 2-3 times in the last three years, 50% of associate and honorary members[17] (n=10) and 66% of affiliate members (n=6) reported visiting other states at that frequency. Moreover, state members were significantly less likely than other members ($p<.01$) to report presenting at national meetings, such as those held by the National Academies of Sciences, Engineering, and Medicine, with just 22% of state members reporting engagement in such presentations at least 2-3 times in the last three years, compared to 58% of associate and honorary members, and 67% of affiliate members.

State-Level Activities

A total of 50 respondents reported their frequency of participation in various state-level activities during the previous year. These activities centered in five areas: (1) standards and curriculum, (2) assessment, (3) professional development, (4) partnerships, and (5) awards.

Standards and curriculum. State science leaders tended to engage more often in standards development or review than in the adoption of curriculum. Fifty-three percent (n=25) of respondents indicated often or all the time serving in lead roles to review or develop state science standards, and 44% (n=20) indicated serving in support roles often or all the time (see Figure 3a). On the other hand, 37% of respondents (n=19) reported that they never consulted with curriculum companies on products in the design phase, and a full 59% of respondents (n=30) indicated never organizing state curriculum adoption. Thus, although state science leaders were involved in policy decisions related to state standards, they were less involved with the implementation of curriculum that reflected those standards.

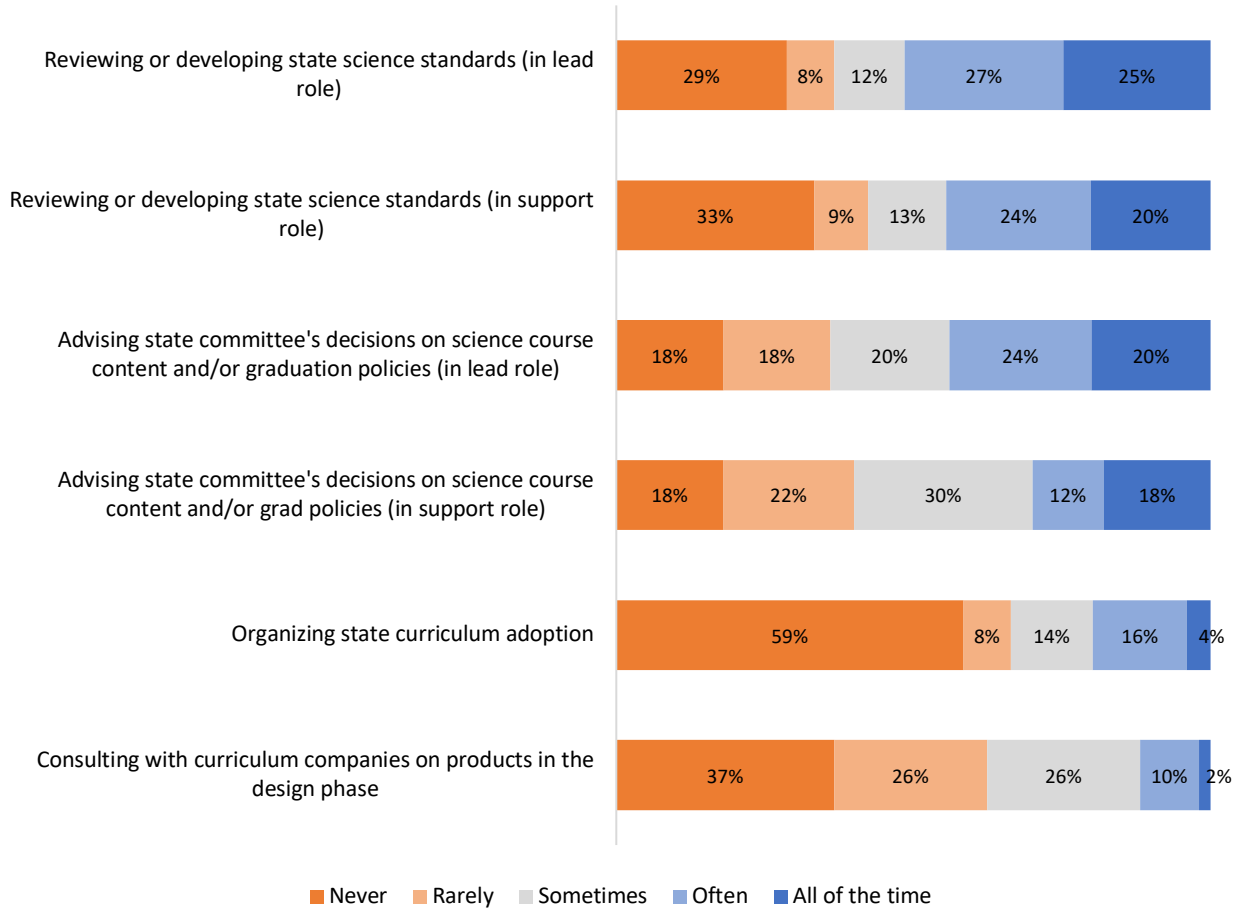

Figure 3a. Frequency of Engagement in State-level Activities, Standards and Curriculum (n=50).

Assessment. Respondents were more likely to report involvement in designing state assessments than selecting contractors for state assessments. Specifically, 56% of respondents (n=28) indicated that they played a support role in designing state assessments often or all the time, while 36% (n=18) reported playing a lead role (see Figure 3b). Conversely, only 26% (n=13) reported selecting contractors for state assessments at that frequency. These findings indicate that many state science leaders played key roles in assessment, but few had authority to make decisions consequential for statewide testing.

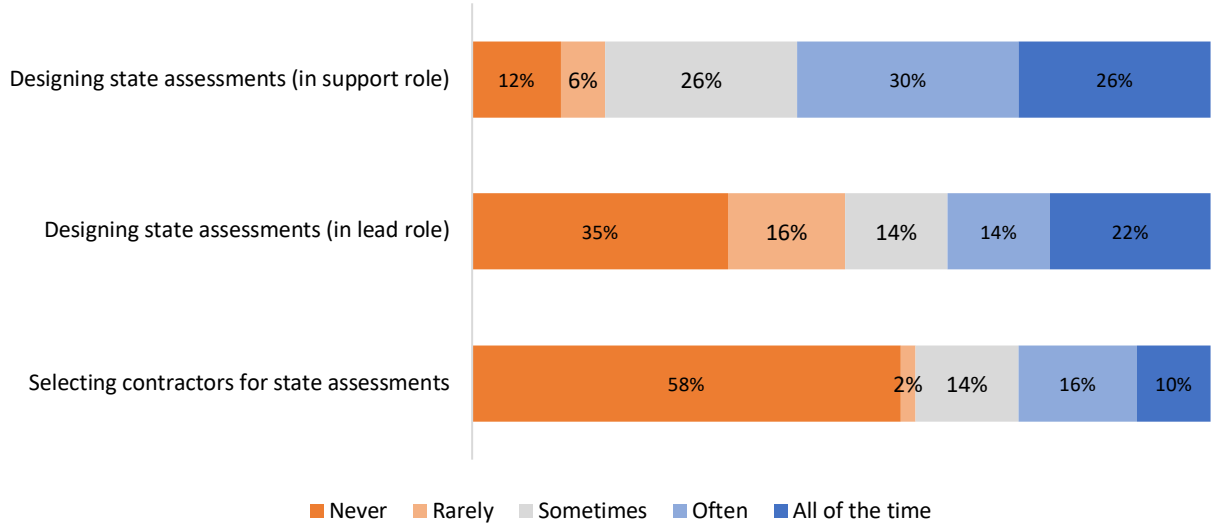

Figure 3b. Frequency of Engagement in State-level Activities, Assessment (n=50).

Professional development. Respondents reported being highly involved in designing or conducting professional development in their states, and less involved in allocating resources or contacting PD providers. A full 77% (n=39) of respondents reported conducting professional development often or all the time (see Figure 3c). Further, 72% (n=37) indicated that they led the design of professional development often or all the time, while 62% (n=31) reported playing a support role at that frequency. On the other hand, respondents were less likely to report identifying vendors to provide PD, writing contracts for professional development, or allocating Title 2A funds, with just 24% (n=12), 26% (n=13), and 10% (n=5), respectively, reporting involvement in these activities often or all the time. As with assessment, these findings suggest that, although CSSS members were highly involved in state professional development, most had limited authority to allocate resources to support it.

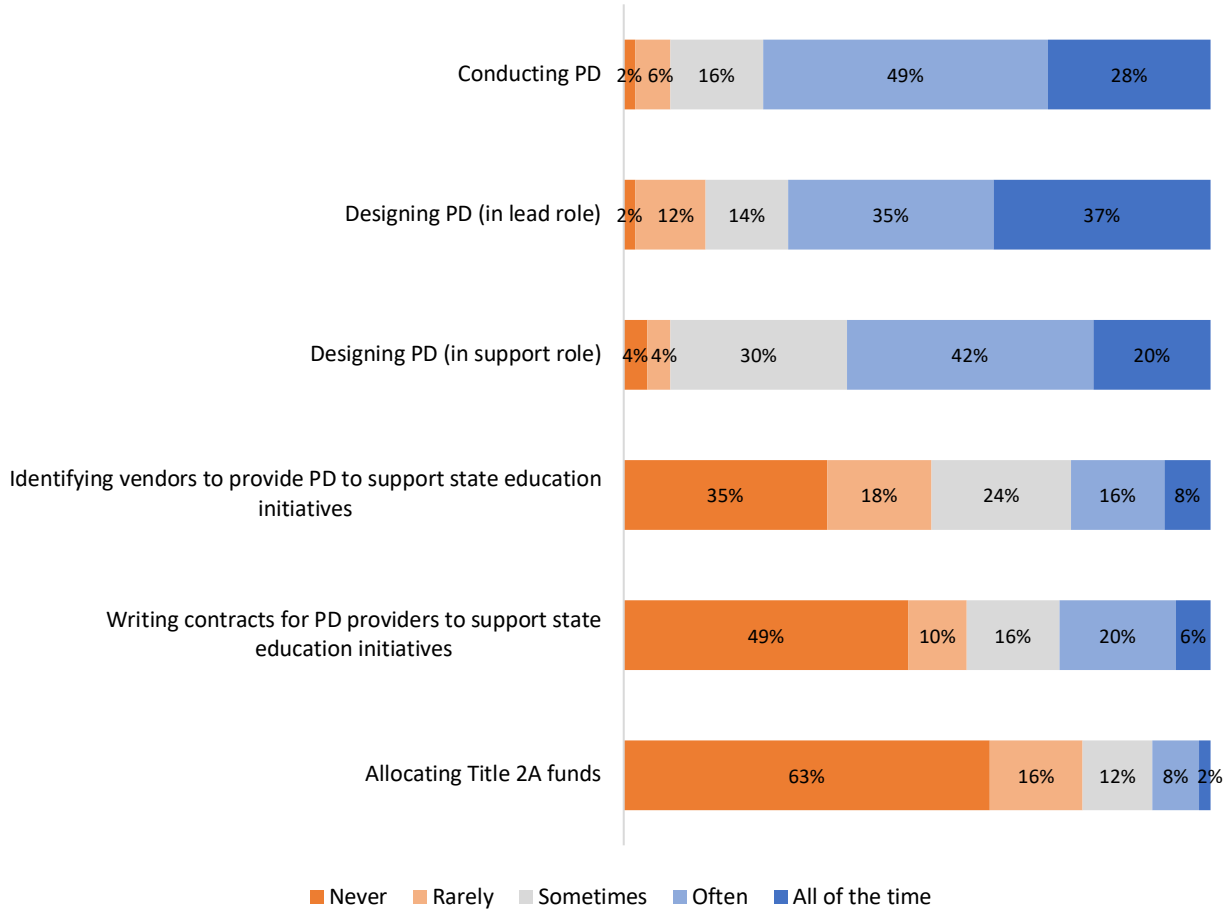

Figure 3c. Frequency of Engagement in State-level Activities, Professional Development (n=50).

The only significant difference in any reported activities between respondents in Year 1 and 2 (n=33) was in their frequency of involvement with writing contracts for PD providers. In Year 2, respondents were significantly less likely to be involved in this activity ($p<.05$), which could be related to federal changes that ended Math Science Partnership (MSP) funding, which many state science supervisors had helped to manage.

Partnerships. Respondents tended to engage more often in resource sharing with districts as opposed to establishing collaborations with their state university systems. They most frequently reported identifying resources to share with districts, or screening or reviewing resources to share with districts, with 80% (n=31) and 63% (n=32) of respondents reporting doing so often or all of the time, respectively (see Figure 3d). Then, 53% (n=27) reported establishing partnerships with business, industry, or non-formal groups often or all the time, and 49% (n=25) reported collaborating with state university systems at that frequency.

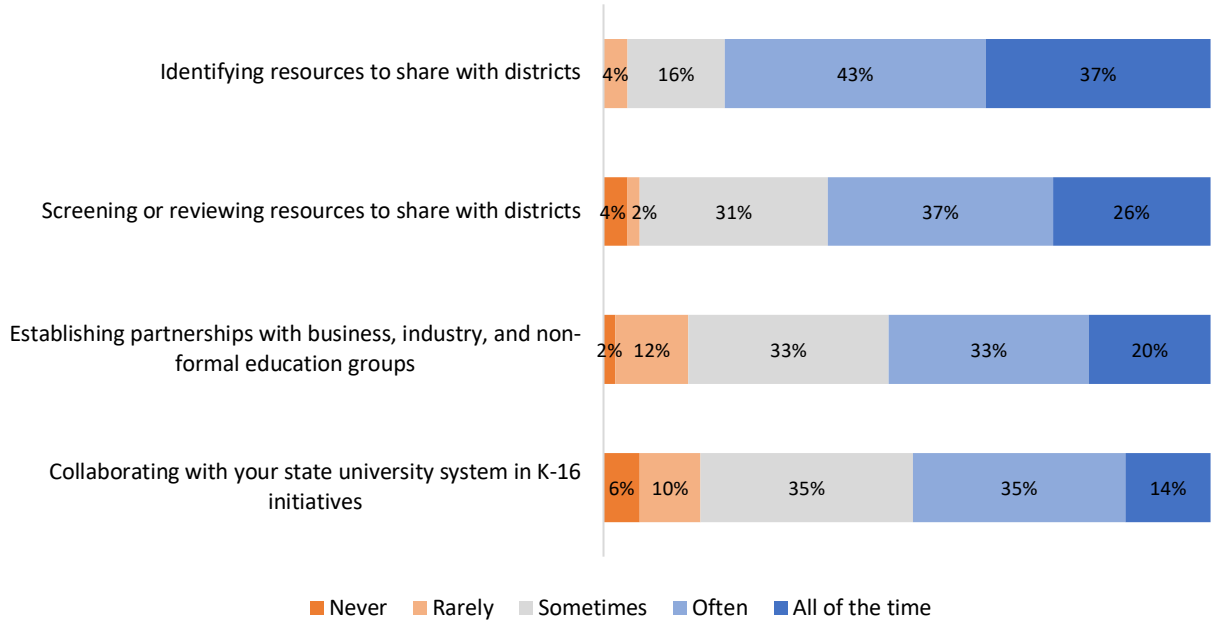

Figure 3d. Frequency of Engagement in State-level Activities, Partnerships (n=51).

Awards. Although respondents were not as frequently engaged in state-level awards as the other types of activities described above, two-thirds reported engaging in these activities at some point in the previous 12 months. Forty percent of respondents (n=20) reported coordinating teacher awards, such as Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST), 28% (n=14) reported coordinating student scholarships, and 26% (n=13) reported conducting grant competitions often or all of the time (see Figure 3e).

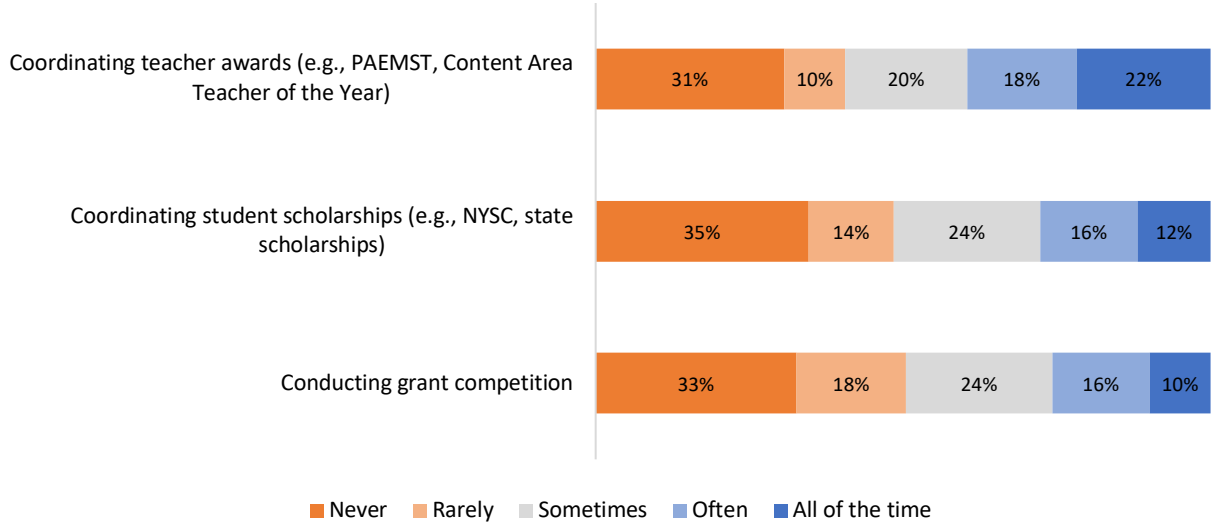

Figure 3e. Frequency of Engagement in State-level Activities, Awards (n=51).

Teacher Professional Development

We asked respondents to characterize the best opportunity in their states for teachers to learn about the *Framework*. Survey questions focused on eliciting attributes related to evidence-based practices reflected in recent consensus volumes (e.g., NASEM, 2015) and in the CSSS' own *Science Professional Learning Standards* (Shaw et al., 2018). In relation to the best professional development (PD) offered in the last year, the majority (63% or n=34) of respondents reported that a state agency led the experience. Other frequent PD facilitators were district leaders and science teachers (reported by 39% and 32% of respondents, respectively). Twenty-seven percent of respondents also identified "other" PD leaders, including regional agencies (e.g., county offices of education), intermediary organizations, university faculty, or consultants. With regard to consultants, 24% of respondents indicated that an individual connected to CSSS led the PD, compared to 9% who indicated that someone not connected to CSSS led the PD.

With respect to funding, the majority indicated that the PD was funded by one of two types of federal grants. A full 57% (n=33) indicated the PD was supported by a Teacher Quality Partnership grant, which are part of a program contained within Title II of the Higher Education Act designed to improve the preparation of prospective teachers and enhance professional development activities for new teachers. Another 15% of respondents (n=7) indicated that the PD was funded by a Supporting Effective Educator Development (SEED) grant, which was a program appropriated in the federal *Every Student Succeeds Act* (ESSA) that supports the implementation of evidence-based preparation, development, or enhancement opportunities for educators. The remaining respondents indicated that PD funding came from other sources, such as foundations or state-specific agencies.

In terms of PD characteristics, we asked respondents about duration as well as the extent to which the PD afforded teachers with opportunities for collective participation, that is, learning with and from peers.[18] Related to duration, the majority of respondents (60% or n=32) indicated that the PD lasted between one and five days. Concerning collective participation, the majority of respondents (51%) reported that the PD afforded participants between 8 and 16 hours (i.e., 1-2 days) of collective participation.

Finally, we asked about the foci of PD that respondents felt offered teachers the best learning opportunities related to the *Framework*. In general, respondents indicated that this PD covered foundational concepts such as: (1) the three dimensions of science learning in the *Framework* or *Next Generation Science Standards* (NGSS), or (2) instructional planning aligned to the NGSS. They indicated that less attention was paid to three-dimensional assessments and developing students' skill in asking questions or designing solutions. Specifically, a full 88% (n=49) of respondents indicated that the three dimensions of science learning in the *Framework* or *Next Generation Science Standards* (NGSS) were a major PD focus, whereas 31% indicated that three-dimensional formative or summative assessment was a major focus (see Figure 4).

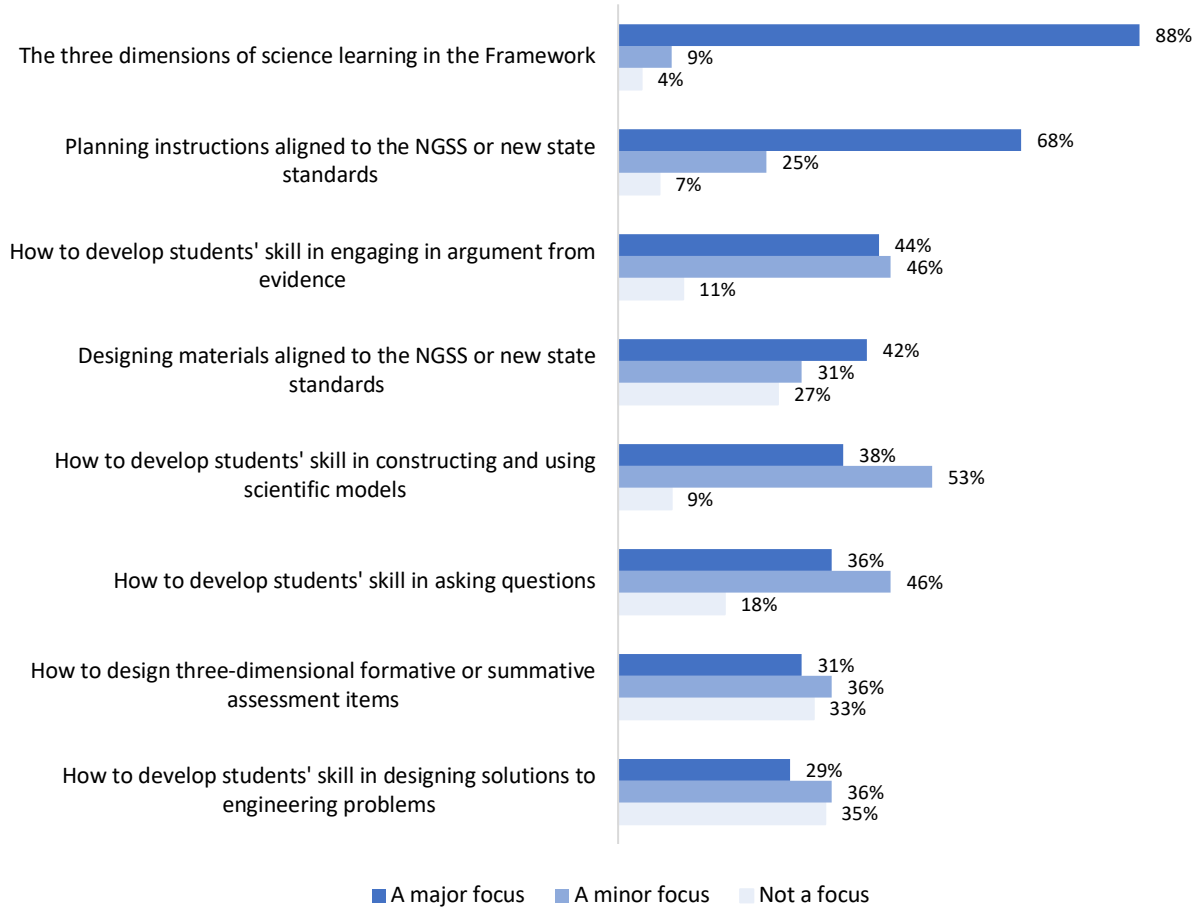

Figure 4. Foci of Professional Development that Respondents Identified as Providing the Best Opportunity for Teachers to Learn about the *Framework* (n=55).

Research Use

Key Findings

- The research respondents reported using to support implementation of the *Framework* most often focused on student learning and classroom assessment, while the research they reported sharing with local leaders most often focused on classroom assessment and pedagogical practices.
- The vast majority of named research did not focus exclusively on the needs or assets of particular student subgroups (e.g., by race/ethnicity, gender, socioeconomic status, or language).
- Research reports or policy briefs, especially those published by the National Academies, as well as peer-reviewed journal articles, comprised the majority the research respondents used and shared.
- The most commonly cited reasons that respondents felt a piece of research was trustworthy were if the findings applied to their state context, or if it gave them new ideas to support implementation of the *Framework*.
- One-third of respondents indicated frequently accessing research through colleagues in their state department of education or through CSSS; few respondents indicated frequently accessing research through NSELA, a parallel professional organization for district leaders, or from the What Works Clearinghouse.
- While the vast majority of respondents reported frequently looking for relevant research studies when confronted with a new problem, fewer reported contacting researchers to find out more about specific articles, especially researchers they did not already know.

Research CSSS Members Use and Share

We asked respondents to identify two pieces of research they use in their work. Research was defined as an activity in which people employ systematic, empirical methods to answer a specific question. First, we asked respondents to name a piece of research they used to inform their state's decisions related to implementation of the *Framework for K-12 Science Education*. Second, we asked respondents to name a piece of research they shared with district or school leaders related to implementation of the *Framework*. Given that respondents who completed the survey at the 2017 CSSS annual meeting did not have Internet access, it is important to keep in mind that they may have been unable to locate specific information for each piece of research; thus, their responses may have been limited in unmeasurable ways.

Research used. With respect to specific pieces of research used to inform state implementation decisions, 17 unique pieces of research were listed by a total of 43 respondents, or 73% of the sample. The most frequently mentioned pieces of research were authored by the National Academies of Science, Engineering, and Medicine (NASEM) and included: *A Framework for K-12 Science Education* (2012), *Guide to implementing the Next Generation Science Standards* (2015), *Developing Assessments for the Next Generation Science Standards* (2014), and *Taking Science to School* (2007) (see Appendix B for a complete list). Respondents also named recently published journal articles, such as: "Climate confusion among U.S. teachers" by Plutzer, McCaffrey, Hannah, Rosenau, Berbeco, and Reid (2016), and "Building an assessment argument to design and use next generation science assessments in efficacy studies of curriculum interventions" by DeBarger, Penuel, Harris, and Kennedy (2016).

Although we observed a higher response rate for this survey item in Year 2 than in Year 1 (2016, 62%; 2017, 73%), as well as a higher total number of responses (2016, n=38; 2017, n=43), the number of unique pieces of research named was fewer: 17 in 2017 as opposed to 26 in 2016. Of the 17 unique pieces of research mentioned in Year 2, nine were also mentioned in Year 1 and most often included National Academies of Science, Engineering, and Medicine publications. Thus, even though the survey sample was more diverse in terms of CSSS membership in Year 2 than in Year 1, there was more congruence across the pieces of research named to support state implementation of the *Framework*.

Research shared. For the second item related to a specific piece of research shared with district or school leaders, 20 unique pieces of research were listed by a total of 37 respondents, or 63% of the sample. These included NASEM publications, such as *Developing Assessments for the Next Generation Science Standards* (2014) and *Guide to Implementing the Next Generation Science Standards* (2015) and a range of journal articles, like "Overview: How can we promote equity in science education?" by Bell and Bang (2015), as well as conference presentations and practice guides. As with the first item, even though there was a higher response rate in Year 2 than in Year 1 (2016, 54%; 2017, 63%), and a higher number of responses (2016, n=33; 2017, N=37), there were fewer unique pieces of research mentioned: 20 in Year 2 compared to 24 in Year 1. Of the 20 pieces mentioned in Year 2, ten were also mentioned in Year 1.

Below, we describe the focus of this research as well as the content areas and student subgroups the pieces of research highlighted. Then, we describe the form of the research referenced by respondents, the reasons it was useful, and with whom it was shared.

Focus of Research

Research used. The 17 unique pieces of research listed by respondents as useful in informing state decisions tended to focus on Teachers and teaching in the classroom (47% or n=8), followed by Student learning and student outcomes (29% or n=5), Assessment (29% or n=5), and School system organization, improvement and reform (6% or n=1) (see Figure 5a).

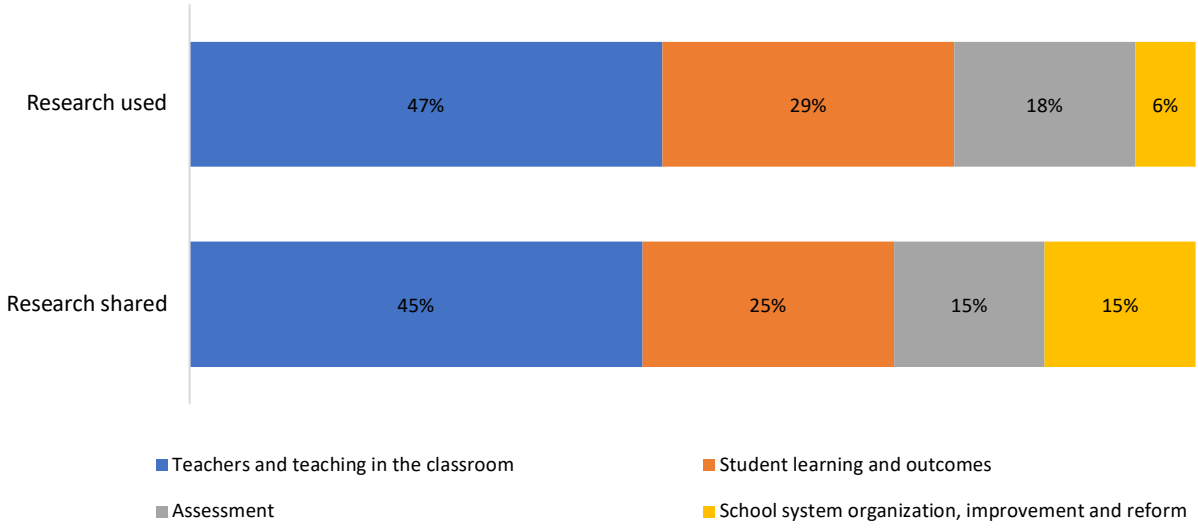

Figure 5a. Focal Topics of Unique Pieces of Research Used (n=17) and Shared (n=20).

However, when looking at the pieces of research named across all respondents (i.e., rather than at unique pieces of research; see Figure 5b below), the majority (40% or n=17) focused on Student learning and student outcomes. All but one piece of research in this topic area focused on student learning and identity development, with the exception of Gonzali-Lee and colleagues' (2015) report *2014-2015 STEM Pathways Evaluation*, which focuses on student achievement and outcomes.

The second most prominent category of research named by respondents was Assessment (26% or n=11 responses). Within this topic area, the main focus was classroom assessment (90% or n=10), with *Developing Assessment for NGSS* by NASEM (2014) most frequently mentioned, as well as a recent journal article, "Building an assessment argument to design and use next generation science assessments in efficacy studies of curriculum interventions," by DeBarger et al. (2016) and published in the *American Journal of Evaluation*. Only one respondent referenced a piece of research focused on standardized testing.

The third most prominent category of research named by respondents was Teachers and teaching in the classroom (21% or n=9). Within this topic area, 55% (n=5) focused on pedagogical practices, such as the 2015 book, *A Vision and Plan for Science Teaching and Learning*, by Brett Moulding (a CSSS honorary member), Rodger Bybee, and Nicole Paulson (a CSSS associate member). Then, 22% (n=2) dealt with teacher effectiveness and evaluation, 11% (n=1) with teacher professional learning, and 11% (n=1) with other subtopics.

The least frequent research topic named by respondents was School system organization, improvement and reform with 14% (n=6) focusing on system improvement, and all referencing the National Academies' 2015 *Guide to Implementing the NGSS*.

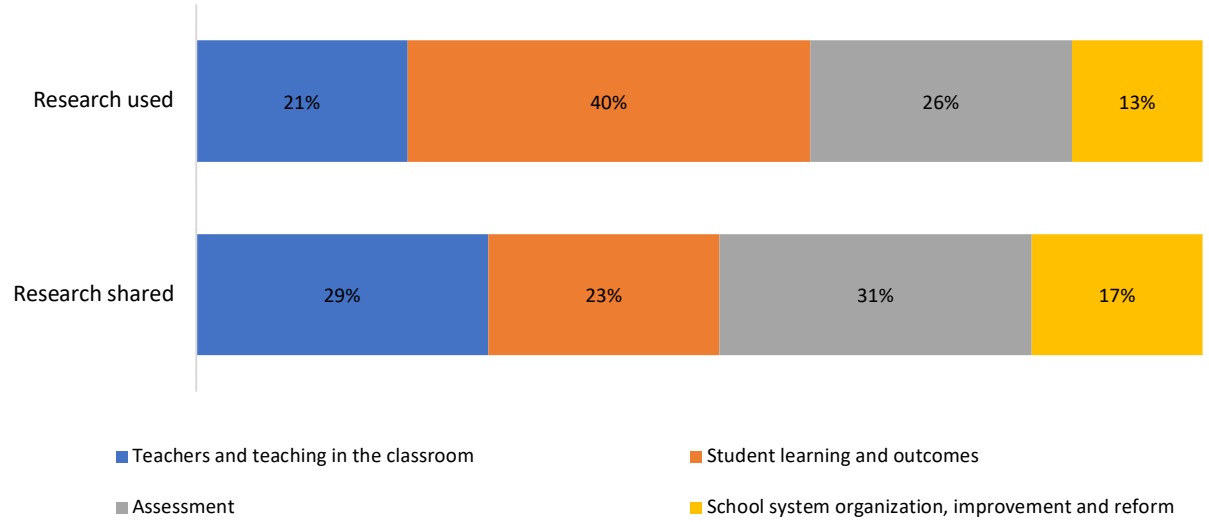

Figure 5b. Focal Topics of Pieces of Research Used (n=43) and Shared (n=37) Across All Respondents.

Research shared with others. Of the 20 unique pieces of identifiable research listed by respondents as shared with district or school leaders, 45% (n=9) focused on Teachers and teaching in the classroom, 25% (n=5) on Student learning and student outcome, 15% (n=3) on Assessment, and 15% (n=3) on School system organization, improvement and reform (see Figure 5a). However, when analyzing the research pieces named across all respondents (i.e., rather than unique pieces of research; see Figure 5b), the most prominent category named was Assessment, with approximately one-third of respondents (31% or n=11) stating that they shared a piece of research related to this topic. Nearly all of these pieces pertained to classroom assessment (91% or n=10) and referenced *Developing Assessments for the Next Generation Science Standards* (NASEM, 2014).

The second most frequent type of research shared by respondents focused on Teachers and teaching in the classroom, with 29% (n=10) of respondents identifying a piece of research on this topic. Half of these pieces focused on pedagogical practices, for example the research brief *Ready, Set, Science* (Michaels et al., 2008). The other half was distributed across the following subtopics: teacher professional learning (30% or n=3), teacher effectiveness and evaluation (10% or n=1), and curriculum (10% or n=1).

The third category of research shared was Student learning and student outcomes, with 23% of respondents (n=8) naming a piece of research related to this topic. The majority (88% or n=7) focused on student learning and identity development, for example citing "Overview: How can we promote equity in science education?" (Bell & Bang, 2015), which highlights the importance of connecting students' interests and experiences to support sense-making in science. The remaining piece of research focused on student achievement and learning outcomes.

With respect to School system organization, improvement and reform, 17% of respondents (n=6) indicated that they shared research related to this topic. A majority of these pieces focused on system improvement (83% or n=5), with most mentioning the *Guide to Implementing the NGSS* (NASEM, 2015). The other piece mentioned was Tate's (2001) article "Science education as a civil right: Urban schools and opportunity-to-learn considerations," which argues that the provision of high-quality science education is a civil rights issue, particularly in segregated urban schools.

Subject matter and subgroups. The overwhelming majority (88% or n=15) of the research pieces used by respondents to inform their state's implementation of the *Framework* focused on science and engineering. Only two pieces focused on other subjects: one on literacy and one on multiple content areas. This distribution was similar for pieces of research respondents indicated sharing with local leaders, with 80% (n=16) focused on science and engineering, 15% (n=3) on general topics, and 5% on literacy (n=1).

Subgroups of students. The vast majority of research studies respondents named did not focus on a particular subgroup primarily or exclusively (n=16 or 94% of research used, and n=17 or 85% of research shared). Of the research used to inform state's decisions, one piece focused on several groups (i.e., SES/poverty, race/ethnicity), while three pieces of research shared with local leaders focused on particular subgroups, with one discussing multiple groups, one focused on English learners, and one examining race and ethnicity. The NASEM consensus volumes that were often named by respondents focus on student subgroups, but not exclusively.

Forms of research. The pieces of research that respondents used to inform their state's implementation decisions included research reports or policy briefs (n=7 or 41%), peer-reviewed journal articles (n=5 or 29%), practitioner-oriented research pieces (n=2 or 12%), and one each of the following: book, research-based tool, and technical report (see Figure 6 below).

The pieces of research respondents mentioned sharing with district or school leaders included research reports or policy briefs (n=7 or 35%), peer-reviewed journal articles (n=3 or 15%), practitioner-oriented research pieces (n=3 or 15%), books (n=2 or 10%), research-based tools (n=2 or 10%), conference presentations (n=2 or 10%), and standards documents (n=2 or 5%). Overall, the forms of research used and shared in Year 2 were more diverse than in Year 1.

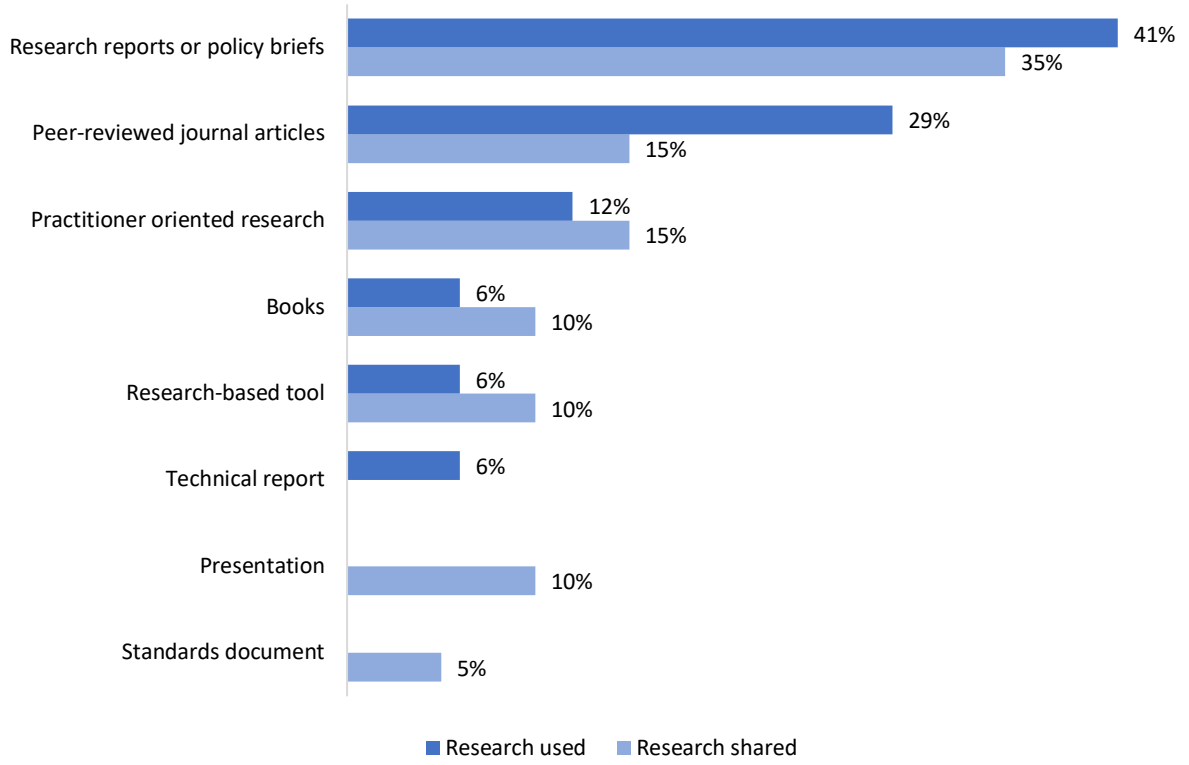

Figure 6. Forms of Research Used (n=17) and Shared (n=20).

Reasons why a piece of research was useful. For the item in which respondents listed a piece of research they used to inform their state's decisions related to implementation of the *Framework*, we also asked "Why was it useful?" Responses from 34 respondents provided enough information to identify reasons. An additional five respondents provided no response, and another four did not provide specific reasons; these nine responses were excluded from the analysis.

Respondents tended to report using a particular piece of research to support their own professional learning (n=11 or 32%), design programs or initiatives (n=9 or 27%), and persuade others about the value of programs or initiatives (n=6 or 18%). Fewer respondents indicated that the research was useful for providing instructional leadership for others in a central office or at school sites (n=2 or 6%), or evaluating programs, policies, initiatives (n=2 or 6%).

Groups with whom research was shared. For the item in which respondents listed a piece of research they shared with local leaders, we also asked "With whom did you share it?" Thirty respondents provided enough information to identify with whom they shared research; five respondents did not provide an answer. Overall, respondents reported sharing research with individuals at a variety of levels, including other state leaders (n=6 or 20%), district leaders (n=5 or 17%), teacher leaders or teachers (n=5 or 17%). And, nearly half of the respondents reported sharing research with more than one level (n=14 or 47%).

Research trustworthiness. Among the 43 respondents that mentioned a piece of research used to inform state decisions about implementation of the *Framework*, 95% (n=41) responded to the item asking what made that research trustworthy. The three most commonly cited reasons were: (1) they could relate the research findings to their state context (78% or n=32), (2) it gave them new ideas to support implementation of the vision of the *Framework* (71% or n=29), and (3) someone they trusted conducted the research (see Figure 7). A less commonly cited reason was if the research methods were rigorous (36% or n=15).

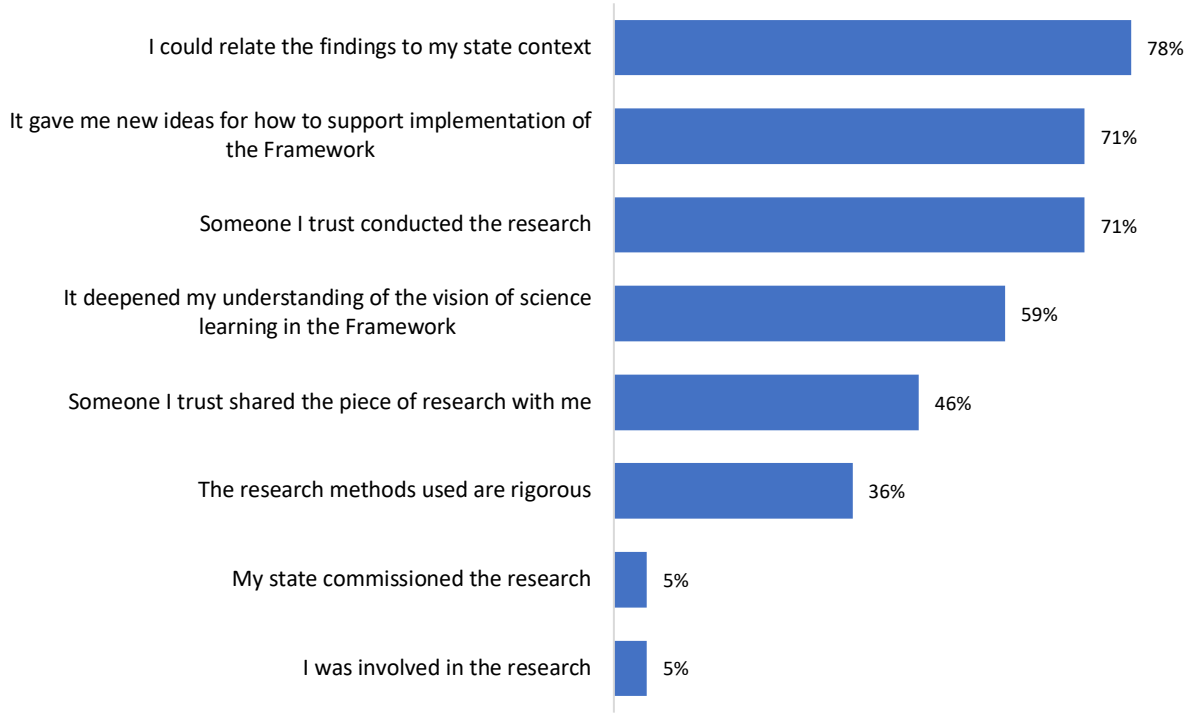

Figure 7. Reasons Why a Piece of Research Was Trustworthy (n=41).

Sources CSSS Members Used to Access Research

A set of survey questions asked respondents to report how often they sought out or acquired research from various sources in the last year (see Figure 8). Respondents to this question (n=58) tended to access research most frequently through formal and informal networks, mainly through CSSS (60% often or all the time, n=35), university researchers (60% often or all the time, n=35), other colleagues in state departments of education (58% often or all the time, n=32), or the National Science Teacher Association (50% often or all the time, n=29). Additionally, research conferences and state consultants were mentioned as prevalent sources of research, with 50% and 23% of respondents reporting seeking out or acquiring research from these sources often or all the time, respectively. Respondents were less likely to report accessing research at that frequency from the National Science Education Leadership Associations (NSELA), vendors (5%, n=3), or the What Works Clearinghouse (7%, n=4). These findings are comparable with Year 1 results.

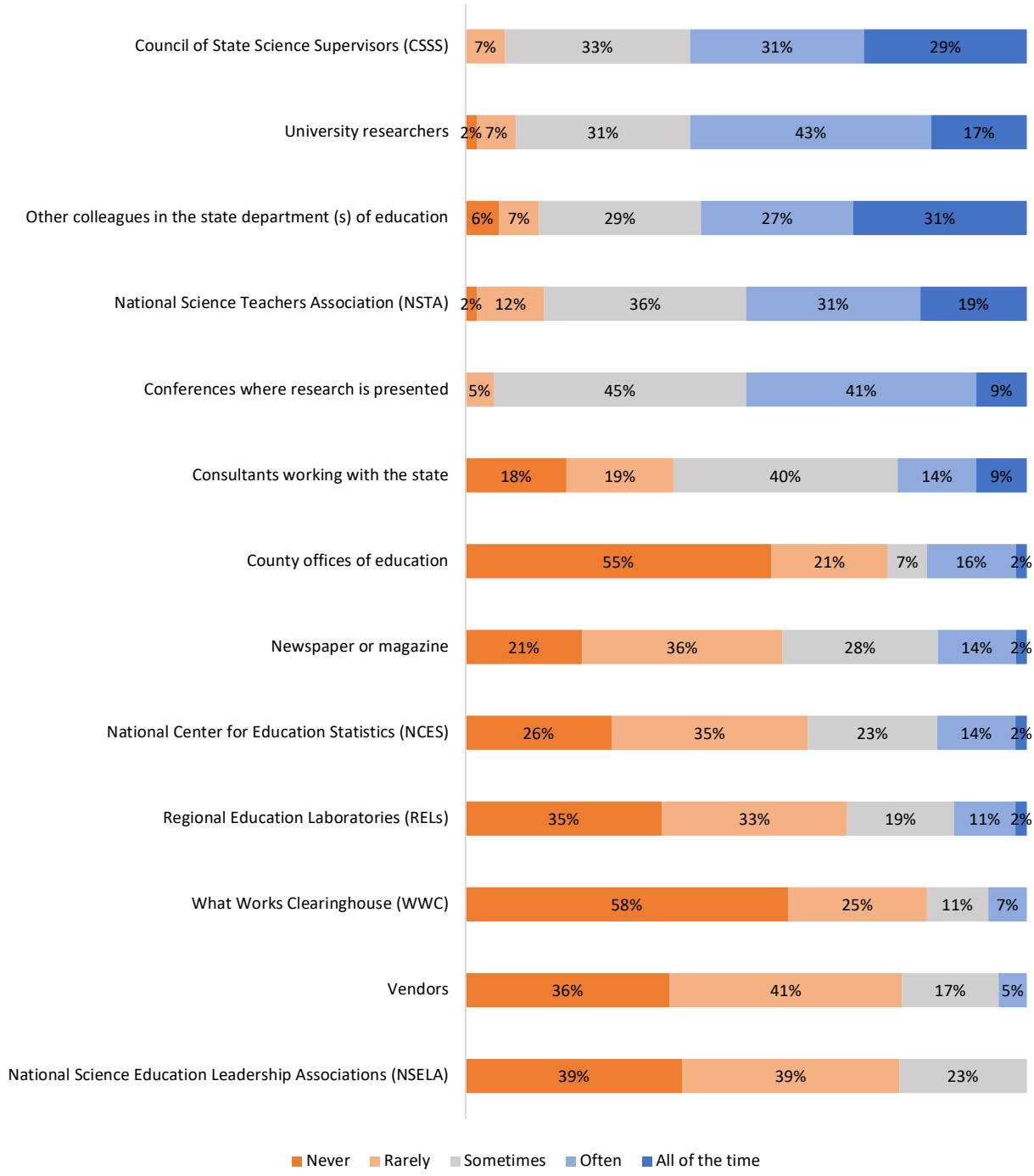

Figure 8. Sources CSSS Members Used to Access Research (n=58).

CSSS Members' Efforts to Acquire Research

We asked respondents five questions related to their efforts to acquire research and to develop relationships with researchers when confronted with new problems or decisions. The vast majority of respondents (n=48 or 83%) reported looking for relevant research studies often or all of the time when confronted with a new problem or decision (see Figure 9). Additionally, they

overwhelmingly indicated (n=46 or 74%) finding it valuable to consult educational research often or all the time when confronted with a new problem or decision. Although 42% of respondents (n=24) reported that they contact researchers they already know often or all of the time, few reported reaching out to researchers to find out more about specific articles at that frequency (n=9 or 15%) or contacting researchers they did not know (n=3 or 5%). These results were similar between Year 1 and Year 2.

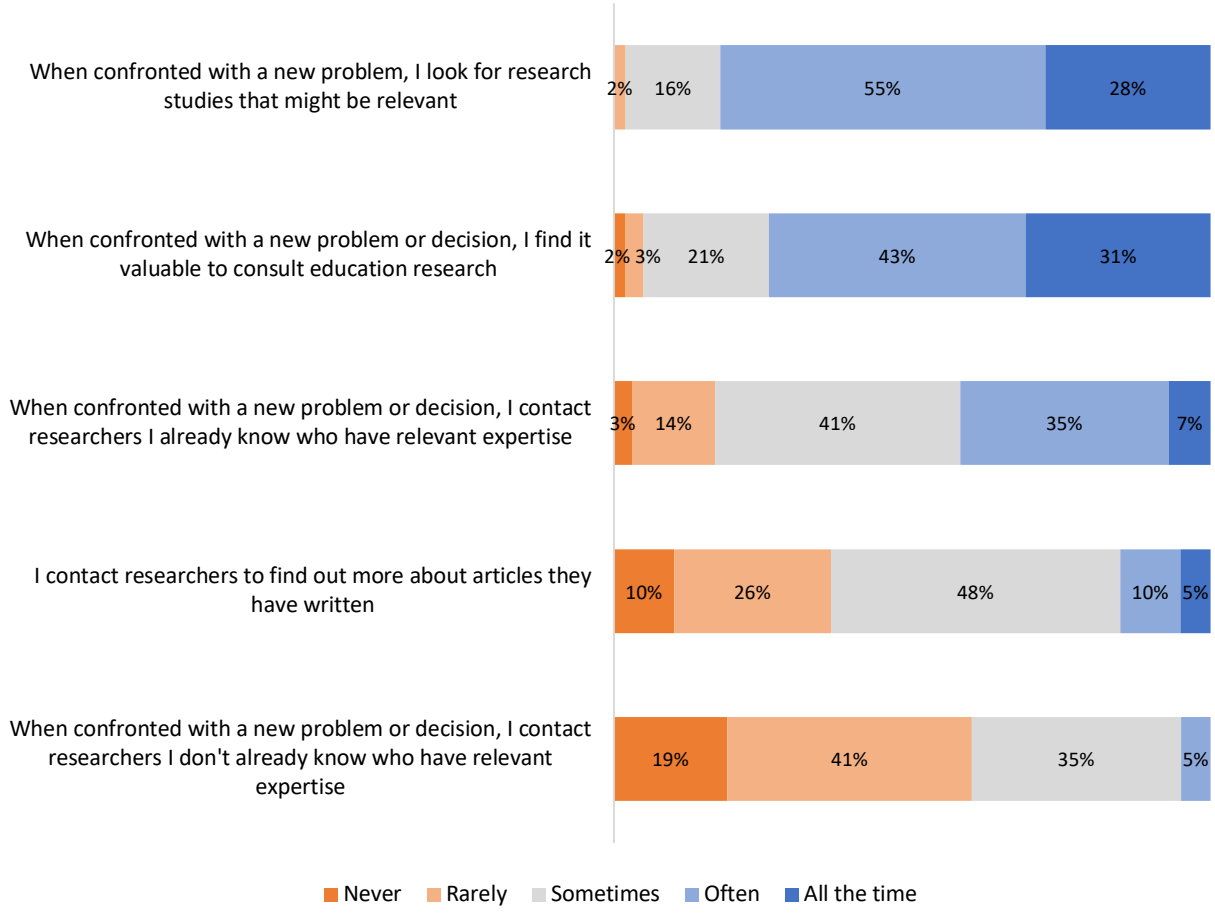

Figure 9. Effort to Acquire Research (n=59).

Research Networks

Key Findings

- Associate, honorary, and affiliate CSSS members served as sources of research to support state implementation of the *Framework* in the areas of curriculum, instruction, assessment, and professional development. University faculty not affiliated with CSSS were also prominent sources of research.
- New CSSS state members were more likely than veteran CSSS members to name individuals from their own state as sources of research.
- While some CSSS members facilitated the exchange of research between members in different states, others facilitated the exchange of research between CSSS members and researchers unaffiliated with the association.
- Formal CSSS activities, particularly substantive meetings, were important for facilitating the exchange of research related to the *Framework*.

CSSS Members' Research Networks

We asked respondents to name individuals to whom they turned in the past year for research to inform their state's efforts to implement the vision of the *Framework for K-12 Science Education*. The findings reported below focus on those interactions that occurred at least 3-4 times per year, in an effort to capture research exchanges that took place outside of the annual CSSS meeting. Although the meeting likely provided state members structured opportunities to share information and ideas, and to come into contact with researchers, we were most interested in the informal interactions occurring outside of this formal networking opportunity. In this section we analyze three aspects of respondents' research-related interactions: (a) how many individuals they turned to for research, and how these relationships were affected by membership type, experience, and research area; (b) what the characteristics of prominent sources and brokers of research were; and (c) whether and how CSSS activities and network characteristics were related.

Research interactions by experience and membership type. We compared respondents' research-related interactions by experience and member type (i.e., state, associate, honorary, and affiliate). To examine differences by experience, we compared results for new state members to more veteran state members, with new members defined as individuals who have been state members for less than two years.

First, we examined how many people each respondent reported turning to for research, a measure called *out-degree centrality*. Table 2 displays summary statistics for this measure for each research topic (i.e., instruction, curriculum, assessment, and professional development), by

member type and experience. These results show that, for all topics, respondents turned to an average of one or two individuals for research. Nonetheless, there were notable differences in out-degree between new and veteran state members. Whereas new state members turned to an average of one individual for research related to instruction, with a maximum of seven, veteran state members turned to an average of two individuals, with a maximum of eleven. Differences were similar for curriculum and assessment, suggesting that veteran members sought out more individuals for research than new members in these areas. However, both new and veteran state members reported turning to an average of two individuals, and a maximum of nine, for research related to professional development.

Table 2. Average Number of Individuals Respondents Turned to for Research.

	Mean	SD	Minimum	Maximum
New state members (n=15)				
Instruction	1.4	2.2	0	7
Curriculum	1.1	1.4	0	4
Assessment	1.1	1.6	0	5
Professional development	1.7	2.6	0	9
Veteran state members (n=26)				
Instruction	2.2	3.2	0	11
Curriculum	1.8	2.6	0	10
Assessment	1.8	2.4	0	7
Professional development	2.2	2.6	0	9
Honorary and associate members (n=11)				
Instruction	1.3	1.6	0	5
Curriculum	0.9	0.9	0	3
Assessment	2.1	3.4	0	11
Professional development	2.1	2.7	0	9
Affiliate members (n=6)				
Instruction	1.8	2.9	0	6
Curriculum	1.3	1.5	0	4
Assessment	1.5	2.1	0	5
Professional development	1.8	3.0	0	7

Second, we categorized the individuals to whom respondents turned for research into six groups: (1) CSSS state member, (2) associate or honorary member, (3) affiliate member, (4) unaffiliated university faculty, (5) intermediary (i.e., a researcher or professional development provider working for an intermediary organization), and (6) state or local leader. Figures 10a-d show the representation of these groups for each research topic and member type.

Results displayed in Figure 10a show that university faculty who were not affiliate members (referred to as "unaffiliated university faculty") were most often named as sources of research related to instruction for new and veteran state members, as well as affiliate members (representing 48%, 38%, and 55% of individuals they sought for instruction-related, respectively). On the other hand, associate and honorary members most often named CSSS affiliates. Further, whereas state members and associate and honorary members named other associate or honorary members as individuals from whom they sought research related to instruction, none of the affiliate members named CSSS associate or honorary members. All types of members, however, indicated turning to state members and intermediaries for research related to instruction.

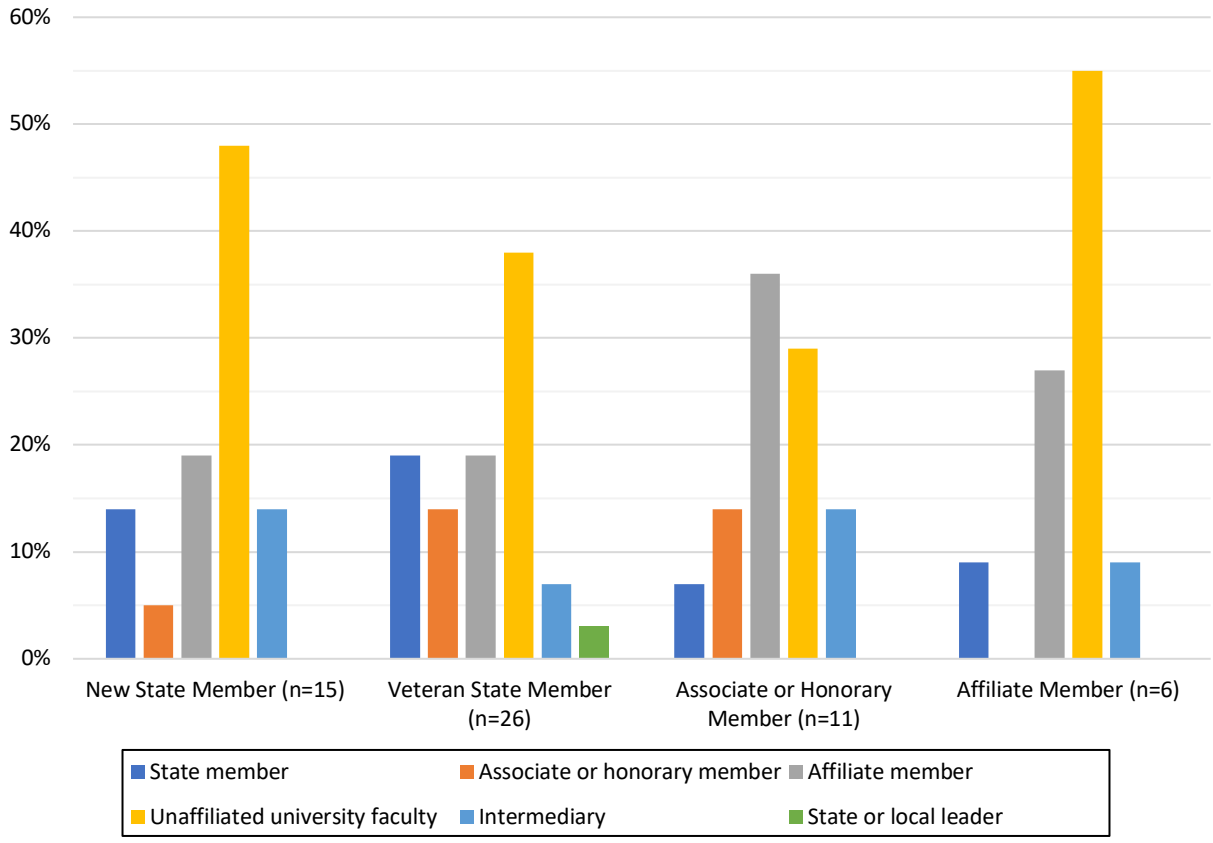

Figure 10a. Composition of Research Interactions Focused on Instruction.

Turning to the individuals that respondents named as sources of research related to curriculum (see Figure 10b), we similarly observed that unaffiliated (i.e., non-member) university faculty were important sources of research in this area for new and veteran state members, as well as for associate and honorary members. Affiliate members, however, were most likely to name other affiliates. Then, while all member types named state members as curriculum-related sources of research, only new and veteran members named associate or honorary members as individuals they turned to for research related to curriculum. As with research related to

instruction, only veteran members named state or local leaders as individuals they turned to for research pertaining to curriculum.

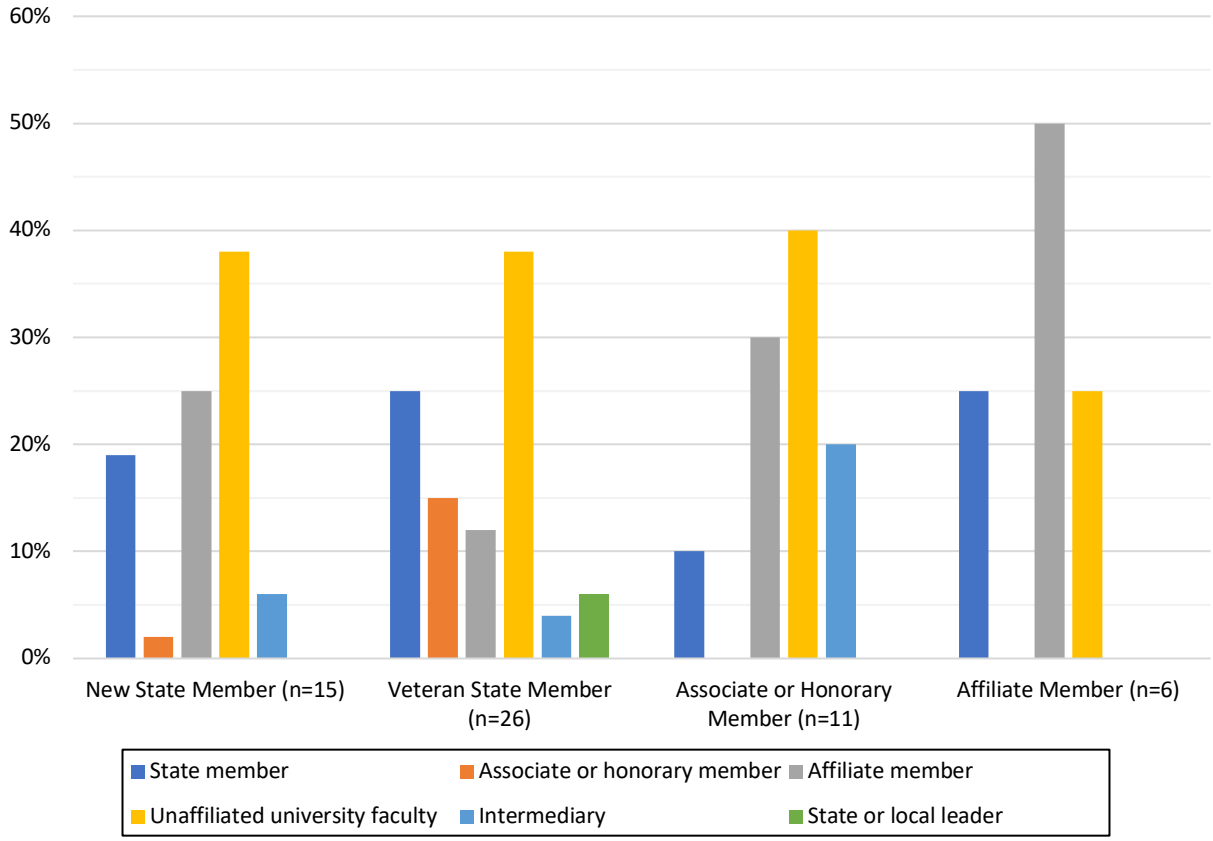

Figure 10b. Composition of Research Interactions Focused on Curriculum

Results for research interactions related to assessment differed, with unaffiliated university faculty named less often, and associate, honorary, and affiliate members serving as key sources of assessment-related research (see Figure 10c). For example, associate and honorary members represented 29% of the individuals to whom new state members turned for research related to assessment, compared to 3% of the individuals that new members named for research related to curriculum. The exception was among affiliate members, who did not name any associate or honorary members. As with instruction and curriculum, state members were named by all member types as sources of research related to assessment. Finally, similar to results for curriculum, affiliate members did not name any intermediaries as sources of research related to assessment, although all other types of members did.

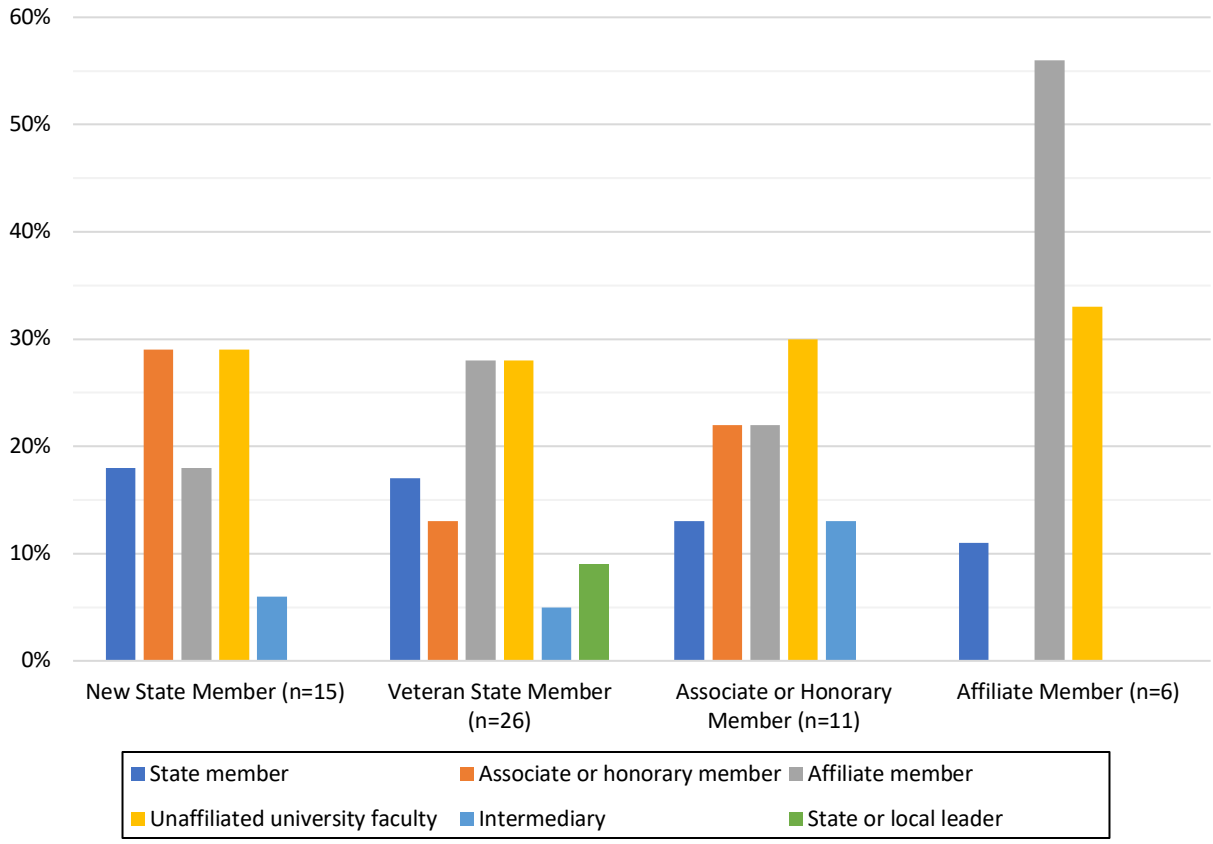

Figure 10c. Composition of Research Interactions Focused on Assessment

With respect to the individuals named as sources of research related to professional development, unaffiliated university faculty were again the most often named by all member types (see Figure 10d). Affiliate members also remained prominent, as did state, associate, and honorary members. The exception was for affiliate members, who did not name any associate or honorary members as individuals they turned to for professional development-related research; however, intermediaries represented a large proportion of their sources of research in this area.

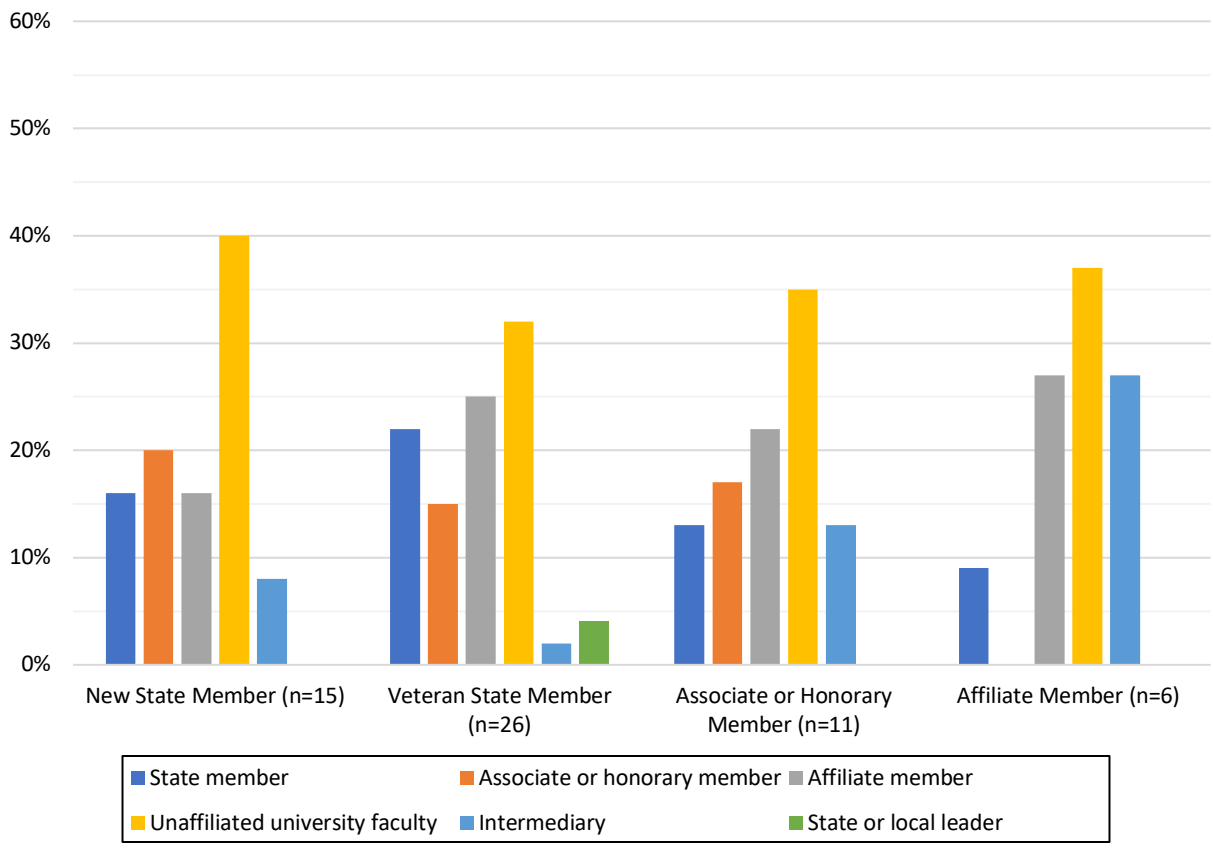

Figure 10d. Composition of Research Interactions Focused on Professional Development

Third, we examined the extent to which respondents named individuals within their own states as sources of research related to each topic area (see Table 3). Our results showed that new state members were twice as likely than veteran members to name individuals from their own state as sources of research related to instruction, curriculum, assessment, and professional development. Additionally, associate and honorary members often named individuals within their own state for research related to curriculum. Finally, affiliate members rarely named individuals from their own states as sources of research in any area.

Table 3. Proportion of Research Interactions that were Within State.

	New State Members (n=15)	**Veteran State Members (n=26)**	**Associate or Honorary Members (n=11)**	**Affiliate Members (n=6)**
Instruction	57%	32%	43%	9%
Curriculum	50	35	60	13
Assessment	47	28	36	11
Professional development	64	31	43	9

Prominent sources and brokers of research. To understand the kinds of individuals who might have the most influence on the research ideas exchanged among CSSS members, we identified the most prominent sources and brokers of research in the network. To identify prominent sources, we calculated *in-degree centrality*, or the number of individuals who named each person in the network, for each research topic. We considered anyone who was named by more than two people as a prominent source of research in that network. Across all research areas (i.e., instruction, curriculum, assessment, and professional development), nine individuals emerged as particularly influential; they are described in Table 4 below. Six of those nine individuals were the same across all four areas and include: two affiliate members, one honorary member, one associate member, one state member, and one unaffiliated university faculty member.

Table 4. Individuals Most Frequently Named as Sources of Research.

			Number of Individuals Who Named Each Person			
No.	**Member Type**	**Organization Type**	**Instruction**	**Curriculum**	**Assessment**	**Professional Development**
1	Affiliate	University	9	6	12	11
2	Affiliate	University	9	6	10	11
3	Honorary	Intermediary	5	8	6	10
4	Associate	Intermediary	4	3	4	4
5	State	Department of Education	3	4	3	5
6	Unaffiliated	University	4	4	3	4
7	Associate	Intermediary	0	0	6	5
8	State	Department of Education	3	0	0	0
9	Unaffiliated	University	0	3	0	0

To explore how brokers might influence the kinds of research shared in the network, we calculated a measure called *betweenness centrality*. This measure allowed us to identify those individuals who facilitated the exchange of research between two individuals who would not otherwise be connected. As an example, person B in Figure 11 below serves as a broker between person A and C, as person A goes to B for research, and B goes to C for research, but A and C are

not connected. On the other hand, person B is not a broker between person C and person D, as they are already connected.

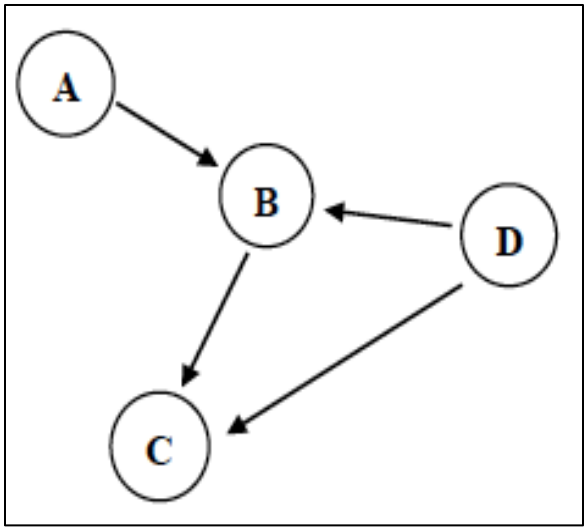

Figure 11. *Example of a Broker.*

Given the nature of brokering, only individuals who responded to the survey can be identified as research brokers. Across all four research areas, three individuals emerged as key brokers: one state member, one associate member, and one affiliate member, and each played different kinds of brokering roles within the association and among states. For instance, the state member tended to broker research between unaffiliated university faculty within their state and state and affiliate members in other states. In this way, they facilitated CSSS members' access to research conducted by unaffiliated academics in their state. The associate member, in contrast, facilitated state members' access to research used by associate, honorary, and affiliate members in different states. The affiliate member also facilitated state members' access to research from other CSSS affiliates, but they also brokered connections between members and unaffiliated university faculty. These exchanges occurred between individuals from within and outside of the affiliate member's state.

Relating Association Activities and Research Networks

As a final step in our analysis, we examined relationships between respondents' reported engagement in CSSS activities (see Figure 2) and the extent to which they were sought out for research related to the *Framework* or served as a broker of such research. Although the small sample size (n=42) limited the extent to which these relationships could reach significance, we found that respondents' participation in formal CSSS meetings were positively and significantly associated with both the number of individuals who named them as sources of research (i.e., in-degree centrality), and the extent to which they served as a broker in the research network (i.e., betweenness centrality).

Specifically, respondents who indicated more frequent participation in CSSS annual meetings over the previous three years were significantly more likely to be sought out for research related to the *Framework*, and these relationships were significant across all research topics (i.e., curriculum ($r(41)=0.42$, $p<.01$), instruction ($r(41)=0.36$, $p<.05$), assessment ($r(41)=0.39$, $p<.05$), and professional development ($r(41)=0.37$, $p<.01$)).

Further, respondents who reported more frequent participation in BCSSE meetings over the previous three years were significantly more likely to be sought out for research, and to serve as research brokers. These relationships were significant across all research topics for the former (curriculum ($r(41)=0.54$, $p<.001$), instruction ($r(41)=0.45$, $p<.01$), assessment ($r(41)=0.50$, $p<.01$), and professional development ($r(41)=0.49$, $p<.01$)), and for two of four topics for the latter (curriculum ($r(41)=0.37$, $p<.05$), instruction ($r(41)=0.31$, $p<.10$), assessment ($r(41)=0.41$, $p<.05$), and professional development ($r(41)=0.21$, $p<.21$)). These findings suggest that formal CSSS activities, and particularly substantive meetings, rather than organizational meetings (i.e., committee meetings) and more informal activities (e.g., webinars), are important for facilitating the exchange of research related to the *Framework* among CSSS members.

Key Conclusions

Findings from this study suggest that CSSS members were highly engaged in state decisions related to science standards and assessments, but were less involved with the implementation of curricula or in decisions related to resource allocation or contract selection. They were also highly involved in the design and implementation of professional development, the best of which tended to focus on foundational concepts in the *Framework for K-12 Science Education*.

With respect to the kinds of research that CSSS members found useful and shared with others, consensus reports by the National Academies of Science, Engineering, and Medicine were particularly prominent. Although these reports often touch on the needs and assets of specific students (e.g., by race/ethnicity, socioeconomic status, gender, or language), very few of the research pieces that CSSS members used or shared focused exclusively on fostering equitable science learning opportunities for particular subgroups. In the context of changing demographics, it will be important to consider whether and how science education reforms are implemented with consideration for students across race, gender, socioeconomics, and language, and for research to address these issues.

Furthermore, given that school system organization and reform was the least frequently mentioned topic of research, it will be important for members to consider scholarship on organizational change and the development of infrastructures to foster coherence across levels of the system. Examining research on both equity and school system reform is especially important given CSSS' current emphasis on building coherent and equitable systems of science education via the ACESSE project. The recent NASEM report (2018) focused on transforming teaching and learning for English learners (ELs) in STEM may be useful in addressing these research areas, as well as the broader scholarship on designing systems with coherence and equity in mind.[19]

CSSS members reported regularly using research to inform their state's decisions related to implementation of the *Framework*. They tended to access research through their networks, such as from CSSS or state department of education colleagues, rather than via other research outlets such as governmental websites. Moreover, broad engagement in CSSS networks, especially through substantive meetings, appeared to facilitate the use of research more than activities like planning meetings or webinars. Findings also showed that the CSSS membership structure was important for facilitating the exchange of research related to statewide implementation of the *Framework*, as associate, honorary, and affiliate members were all key sources of research.

In conclusion, state science leaders tended to access and make use of relevant research to inform state-level efforts to implement the *Framework*, and had a robust and well-connected research network. At the same time, this study identified potential areas of growth to amplify the strategic place these leaders hold in the process of providing a quality science education to an increasingly diverse population of students.

Appendices

Appendix A. Survey Instrument

Survey: Research Use Among State Science Leaders

To begin, please provide the following information. While we need this information to track responses over time, please remember that you will be assigned a study ID number, and will never be identified by name in the dataset or in any data reports.

1. First name: _____
2. Last name: _____
3. Job title: _____
4. Organizational affiliation (if applicable): _____
5. State: _____
6. I am a: [MARK ALL THAT APPLY]
   - ☐ Current CSSS member
   - ☐ Former CSSS member
   - ☐ CSSS affiliate member

Definition of Research: For the purposes of this study, "research" is an activity in which people employ systematic, empirical methods to answer a specific question. Research, as we define it, is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

The next set of questions ask about your use of research related to implementation of the *Framework for K-12 Science Education*.

7. First, think about a time **when you used a piece of research to inform a decision in your state** related to the implementation of the *Framework for K-12 Science Education*. What was that piece of research? While you do not need to enter all details, please provide as much information as you can about this piece of research so we can locate it ourselves.

   Title: _____

   Author: _____

   Year Published: _____

   Publisher: _____

   Topic: _____

   Why was this piece of research useful? _____

   _____

   _____

   _____

   _____

   What made this piece of research trustworthy? (MARK ALL THAT APPLY.)

   - ☐ I was involved in the research.
   - ☐ My state commissioned the research.
   - ☐ Someone I trust conducted the research.
   - ☐ Someone I trust shared the piece of research with me.
   - ☐ The research methods used are rigorous.
   - ☐ I could relate the findings to my state context.
   - ☐ It deepened my understanding of the vision of science learning in the *Framework.*
   - ☐ It gave me new ideas for how to support implementation of the *Framework.*
   - ☐ Other: _____

     _____

Definition of Research: For the purposes of this study, "research" is an activity in which people employ systematic, empirical methods to answer a specific question. Research, as we define it, is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

8. Now, think about a **time when you shared a piece of research with district or school leaders** related to the implementation of the *Framework for K-12 Science Education*. What was that piece of research? While you do not need to enter all details, please provide as much information as you can about this piece of research so we can locate it ourselves.

   Title: _____

   Author: _____

   Year Published: _____

   Publisher: _____

   Topic: _____

   With whom did you share this piece of research? _____

   _____

   _____

   Why did you share this piece of research? _____

   _____

   _____

   _____

   _____

Definition of Research: For the purposes of this study, "research" is an activity in which people employ systematic, empirical methods to answer a specific question. Research, as we define it, is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

9. How often do you do each of the following?

	Never	Rarely	Sometimes	Often	All of the time
A. I contact researchers to find out more about articles they have written.	☐	☐	☐	☐	☐
B. When confronted with a new problem or decision, I contact researchers I already know who have relevant expertise.	☐	☐	☐	☐	☐
C. When confronted with a new problem or decision, I contact researchers I don't already know who have relevant expertise.	☐	☐	☐	☐	☐
D. When confronted with a new problem or decision, I look for research studies that might be relevant.	☐	☐	☐	☐	☐
E. When confronted with a new problem or decision, I find it valuable to consult education research.	☐	☐	☐	☐	☐

Definition of Research: For the purposes of this study, "research" is an activity in which people employ systematic, empirical methods to answer a specific question. Research, as we define it, is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

10. In the past 12 months, to whom have you turned for research that can inform your state's efforts to implement the vision of the *Framework for K-12 Science Education*? Please include up to 10 researchers, state science supervisors, or other colleagues, within or outside your state. For each person listed, please indicate their organization, the frequency with which you interacted with them, and the general topics of research discussed. You do not need to fill in all the spaces. While we ask you to include individual names, all individuals will be assigned an ID number and will ever identified by name in datasets or data reports.

		How often do you turn to each person for research?						**What topics of research do you discuss? MARK ALL THAT APPLY.**			
First and Last Name	**Organization**	1-2 times per year	3-4 times per year	Every 2 months or so	Monthly	2-3 times per month	Weekly	Curriculum	Assessment	Professional development	Instruction
1.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10.		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Definition of Research: For the purposes of this study, "research" is an activity in which people employ systematic, empirical methods to answer a specific question. Research, as we define it, is different than the practice of looking at data from the district, school, or classroom, which is more open-ended and seldom addresses specific research questions.

11. During the past 12 months, how often have you sought out or acquired research from the following sources?

	Never	Rarely	Sometimes	Often	All of the time
A. National Science Teachers Association (NSTA)	☐	☐	☐	☐	☐
B. National Science Education Leadership Association (NSELA)	☐	☐	☐	☐	☐
C. Council of State Science Supervisors (CSSS)	☐	☐	☐	☐	☐
D. University researchers	☐	☐	☐	☐	☐
E. Regional Education Laboratories (RELs)	☐	☐	☐	☐	☐
F. County offices of education	☐	☐	☐	☐	☐
G. Other colleagues in the state department(s) of education	☐	☐	☐	☐	☐
H. National Center for Education Statistics (NCES)	☐	☐	☐	☐	☐
I. What Works Clearinghouse (WWC)	☐	☐	☐	☐	☐
J. Newspaper or magazine	☐	☐	☐	☐	☐
K. Vendors	☐	☐	☐	☐	☐
L. Consultants working with the state	☐	☐	☐	☐	☐
M. Conferences where research is presented	☐	☐	☐	☐	☐

The next set of questions asks about your work as a state science leader.

12. In the last 12 months, how often have you engaged in the following activities as part of your role as a state science leader?

	Never	Rarely	Sometimes	Often	All of the time
Standards & Curriculum					
A. Reviewing or developing state science standards (in lead role)	☐	☐	☐	☐	☐
B. Reviewing or developing state science standards (in support role)	☐	☐	☐	☐	☐
C. Organizing state curriculum adoption	☐	☐	☐	☐	☐
D. Consulting with curriculum companies on products in the design phase	☐	☐	☐	☐	☐
E. Advising state committee's decisions on science course content and/or graduation policies (in lead role)	☐	☐	☐	☐	☐
F. Advising state committee's decisions on science course content and/or graduation policies (in support role)	☐	☐	☐	☐	☐
Assessments					
G. Designing state assessments (in lead role)	☐	☐	☐	☐	☐
H. Designing state assessments (in support role)	☐	☐	☐	☐	☐
I. Selecting contractors for state assessments	☐	☐	☐	☐	☐
Professional Development					
J. Allocating Title 2A funds	☐	☐	☐	☐	☐
K. Identifying vendors to provide professional development to support state education initiatives	☐	☐	☐	☐	☐

	Never	Rarely	Sometimes	Often	All of the time
L. Writing contracts for professional development providers to support state education initiatives	☐	☐	☐	☐	☐
M. Designing professional development (in lead role)	☐	☐	☐	☐	☐
N. Designing professional development (in support role)	☐	☐	☐	☐	☐
O. Conducting professional development	☐	☐	☐	☐	☐
Partnerships					
P. Identifying resources to share with districts	☐	☐	☐	☐	☐
Q. Screening or reviewing resources to share with districts	☐	☐	☐	☐	☐
R. Collaborating with your state university system in K-16 initiatives	☐	☐	☐	☐	☐
S. Establishing partnerships with business, industry, and non-formal education groups	☐	☐	☐	☐	☐
Awards					
T. Coordinating student scholarships (e.g., NYSC, state scholarships)	☐	☐	☐	☐	☐
U. Coordinating teacher awards (e.g., PAEMST, Content Area Teacher of the Year)	☐	☐	☐	☐	☐
V. Conducting grant competition	☐	☐	☐	☐	☐
Other					
W. Other – Please list:	☐	☐	☐	☐	☐
X. Other – Please list:	☐	☐	☐	☐	☐

The next group of questions ask about professional development (PD) offered in your state. When answering these questions, please think about the PD your state has offered **in the last year** that you think offered the **best opportunity** for teachers to learn about the *Framework for K-12 Science Education.*

13. Who led this professional development? (MARK ALL THAT APPLY)

- ☐ A state agency leader
- ☐ A district leader
- ☐ A science teacher
- ☐ A commercial vendor from within the state
- ☐ A commercial vendor from outside the state
- ☐ An individual consultant who is connected to CSSS
- ☐ An individual consultant who has no connection to CSSS
- ☐ Other – Please specify: _____

14. How much time did participants spend together in professional development?

- ☐ <1 hour
- ☐ 1-2 hours
- ☐ 3-5 hours
- ☐ 6-8 hours
- ☐ 9-16 hours
- ☐ 17-24 hours
- ☐ 25-40 hours
- ☐ 41-80 hours
- ☐ More than 80 hours

15. Over what period of time did the professional development occur?

- ☐ Less than a day
- ☐ One day
- ☐ Two to four days
- ☐ A week
- ☐ A month
- ☐ Two to five months
- ☐ Six to nine months
- ☐ Ten to twelve months
- ☐ More than a year

16. Which topics did the professional development address?

	A major focus	A minor focus	Not a focus
A. The three dimensions of science learning in *The Framework* or NGSS	☐	☐	☐
B. Designing materials aligned to the NGSS or new state standards	☐	☐	☐
C. Planning instruction aligned to the NGSS or new state standards	☐	☐	☐
D. How to develop students' skill in asking questions	☐	☐	☐
E. How to develop students' skill in constructing and using scientific models	☐	☐	☐
F. How to develop students' skill in designing solutions to engineering problems	☐	☐	☐
G. How to develop students' skill in engaging in argument from evidence	☐	☐	☐
H. How to design three-dimensional formative or summative assessment items	☐	☐	☐

17. Below are several funding streams for professional development. Which of these streams will your state use to fund professional development in science in the future, either the group grants to schools and districts or through state programs? (MARK ALL THAT APPLY)

☐ Title II – Teacher Quality Partnership Grants

☐ Title II – Teacher Incentive Grants

☐ Title II – Supporting Effective Educator Development (SEED) Grants

☐ STEM Master Teacher Corps

☐ School Improvement Grants

☐ Other: _____

The next questions ask about your engagement with the Council of State Science Supervisors.

18. What roles have you taken on as a member (current, former, or affiliate) of the Council of State Science Supervisors? (MARK ALL THAT APPLY.)

- ☐ President
- ☐ Secretary
- ☐ Board member
- ☐ Ad-Hoc Committee Chair
- ☐ Ad-Hoc Committee Contributor/Participant
- ☐ Presenter at this year's CSSS conference
- ☐ Presenter at a previous CSSS conference
- ☐ Participant in state science conference
- ☐ Organizer of state science fair
- ☐ Other: _____
- ☐ None of the above

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19. Please indicate which CSSS activities you have participated in over the last three years. For those activities in which you participated, please indicate the frequency as well as how each of the following activities supported your ongoing work.

	In the last three years, about how often have you participated in each activity?				**If you participated in the activity, in what ways did it support your work? (MARK ALL THAT APPLY.)**		
	Never	Once	2-3 times	4 or more times	I learned about research findings.	I learned about research-based tools.	I learned about strategies for addressing issues in my state.
A. CSSS Annual Meeting	☐	☐	☐	☐	☐	☐	☐
B. CSSS Committee Meetings	☐	☐	☐	☐	☐	☐	☐
C. CSSS Board Meetings	☐	☐	☐	☐	☐	☐	☐
D. BCSSE Meetings	☐	☐	☐	☐	☐	☐	☐
E. Collaborating with other states	☐	☐	☐	☐	☐	☐	☐
F. Visiting other states	☐	☐	☐	☐	☐	☐	☐
G. Consulting with CSSS members	☐	☐	☐	☐	☐	☐	☐
H. Presenting at NRC or other national meetings	☐	☐	☐	☐	☐	☐	☐
I. Attending workshops/talks by researchers	☐	☐	☐	☐	☐	☐	☐
J. Participating in CSSS sponsored webinars	☐	☐	☐	☐	☐	☐	☐
K. Reading information from the CSSS listserv	☐	☐	☐	☐	☐	☐	☐

The final set of questions ask for demographic and background information. Your responses will not be used in identifiable ways, but will help us understand patterns across survey participants.

20. Please indicate your race/ethnicity:
    - ☐ White
    - ☐ Black or African American
    - ☐ Latino/Latina or Hispanic
    - ☐ American Indian or Alaska Native
    - ☐ Asian
    - ☐ Native Hawaiian or Other Pacific Islander
    - ☐ Two or more races
    - ☐ Other

21. Please indicate your sex:
    - ☐ Male
    - ☐ Female

22. Including this year, for how many years have you served (or did you serve) as a state science supervisor? _____

23. Including this year, for how many years have you served as an affiliate member of CSSS? _____

24. Which degrees have you acquired? (MARK ALL THAT APPLY)
    - ☐ Associate's degree
    - ☐ Bachelor's degree
    - ☐ Master's degree
    - ☐ Doctoral degree
    - ☐ None of the above
    - ☐ Other: _____

25. Which certifications do you hold or have you held in the past? (MARK ALL THAT APPLY)
    - ☐ Teaching certification (general)
    - ☐ Teaching certification (science)
    - ☐ Administrator certification
    - ☐ None of the above
    - ☐ Other: _____

END OF SURVEY

Appendix B. Complete List of Pieces of Research Named by Respondents, in Alphabetical Order

	Citation	No. of Respondents Who Used It	No. of Respondents Who Shared It
1.	Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research, Inc.	0	1
2.	Bell, P. & Bang, M. (2015). *Overview: How can we promote equity in science education? STEM Teaching Tools Initiative, Institute for Science + Math Education.* Seattle, WA: University of Washington. Retrieved from http://stemteachingtools.org/brief/15	1	2
3.	Council of State Science Supervisors. (2017). *Science Professional Learning Standards.* Professional Learning Committee: Sam Shaw, Brett Moulding, Shari Templeton, Catherine Mackey, William Penuel, Katie Van Horne. Council of State Science Supervisors.	0	1
4.	DeBarger, A., Penuel, W., Harris, C., & Kennedy, C. (2016). Building an Assessment Argument to Design and Use Next Generation Science Assessments in Efficacy Studies of Curriculum Interventions. American Journal of Evaluation, 37(2), 174-192.	1	0
5.	Gozali-Lee, E., Mueller, D., Streich, F., & Bartholomay, A. (2015). *2014-2015 STEM pathways evaluation.* Saint Paul, MN: Wilder Research.	1	0
6.	Hakuta, K., Santos, M., & Fang, Z. (2013). Challenges and Opportunities for Language Learning in the Context of the CCSS and the NGSS. *Journal of Adolescent & Adult Literacy, 56*(6), 451-454.	0	1
7.	Harlen, W. (Ed.) (2015). *Working with big ideas in science education.* Trieste, Italy: Science Education Programme of IAP.	2	2
8.	Klieger, A., & Yakobovitch, A. (2011). Perception of Science Standards' Effectiveness and Their Implementations by Science Teachers. *Journal of Science Education and Technology, 20*(3), 286-299.	1	0
9.	Michaels, S., & O'Connor, C. (2012). *Talk science primer.* Cambridge, MA: TERC.	0	1
10.	Michaels, S., Shouse, A.W., & Schweingruber, H.A. (2008). *Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms.* Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.	0	2

11.	Moulding, B., Bybee, R., & Paulson, N. (2015). *A vision and plan for science teaching and learning.* Salt Lake City, UT: Essential Teaching & Learning PD, LLC.	2	0
12.	Nadelson, L., Seifert, A., & Hendricks, J.K. (2015). Are we preparing the next generation? K-12 teacher knowledge and engagement in teaching core STEM practices. *ASEE Annual Conference and Exposition, Conference Proceedings, 122nd ASEE Annual Conference and Exposition: Making Value for Society*.	0	1
13.	National Academies of Sciences, Engineering, and Medicine. (2015). *Science Teachers' Learning: Enhancing Opportunities, Creating Supportive Contexts.* Committee on Strengthening Science Education through a Teacher Learning Continuum. Board on Science Education and Teacher Advisory Council, Division of Behavioral and Social Science and Education. Washington, DC: The National Academies Press.	1	1
14.	National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten Through Eighth Grade. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse, Editors. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.	6	0
15.	National Research Council. (2012*). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.	7	2
16.	National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessment and Board on Science Education, James W. Pellegrino, Mark R. Wilson, Judith A. Koenig, and Alexandra S. Beatty, Editors. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.	9	9
17.	National Research Council. (2015). *Guide to Implementing the Next Generation Science Standards.* Committee on Guidance on Implementing the Next Generation Science Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education, Washington, DC: The National Academies Press.	6	4
18.	*Next Generation Science Standards.* Retrieved from: https://www.achieve.org/next-generation-science-standards	0	1
19.	Osborne, J. & Patterson, A. (2011). Scientific Argument and Explanation: A necessary Distinction? *Science Education, 95*, 627-638.	1	0
20.	Pearson, D., Moje, E., & Greenleaf, C. (2010). Literacy and Science: Each in the Service of the Other. *Science, 328*(5977), 459-463.	1	0

21.	Penuel, W.R. & Shepard, L.A. (2016). Assessment and teaching. In D.H. Gitomer & C.A. Bell (Eds.), *Handbook of research on* teaching (pp. 787-850). Washington, DC: AERA.	0	1
22.	Plutzer, E., McCaffrey, M., Hannah, A., Rosenau, J., Berbeco, M., & Reid, A. (2016). Climate confusion among U.S. teachers. *Science, 351*(6274), 664-665.	1	0
23.	Popham, J. (2016). *The ABCs of Educational Testing. Demystifying the Tools that Shape Our Schools.* Thousand Oaks, CA: Corwin/Sage.	0	1
24.	*Project 2061.* Retrieved from https://www.aaas.org/program/project2061	1	0
25.	Reiser, B. (2013*). What professional development strategies are needed for successful implementation of the Next Generation Science Standards?* Paper presented at the Research Symposium on Science Assessment, Educational Testing Service, Washington, DC.	0	1
26.	Reiser, B. (2014). *Designing coherent storylines aligned with NGSS for the K-12 classrooms.* Presented at the NSELA conference.	0	1
27.	*Research + Practice Collaboratory.* Retrieved from http://researchandpractice.org/resources/	0	1
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Endnotes

[1] National Research Council (2012)

[2] For the complete survey instrument 2017 see Appendix A.

[3] Penuel, W. R., et al. (2016)

[4] Frank, Zhao, and Borman (2004); Penuel, Frank, Sun, Kim, and Singleton (2013); Spillane, Hopkins, and Sweet (2015).

[5] For findings from the first administration, see: Hopkins, M. (2016).

[6] Goertz, Barnes, Massell, Fink, and Francis (2013)

[7] Massell, Goertz, and Barnes (2012)

[8] National Research Council (2012)

[9] National Research Council (1999, 2005, 2007, 2009)

[10] See, for example, Knorr-Cetina (1999); Pickering (1995).

[11] NGSS Lead States (2013)

[12] New NASEM report on ELs in STEM (2018)

[13] Penuel, W. R., et al. (2016)

[14] Landry, R., Lamari, M., and Amara, N. (2003)

[15] Penuel et al. (2017)

[16] Results are based on a one-way analysis of variance (ANOVA).

[17] To facilitate our analysis, we grouped associate and honorary members because both have a history of service to CSSS.

[18] See Desimone, L. M. (2009).

[19] See, for example, Hopkins & Spillane (2015) and Penuel (in press).